Long Term Stewardship Technology Analysis of the Office of Science and Technology Profile

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Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho 83415

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ACRONYMS

CFR	Code of Federal Regulation
CMST	Characterization, Monitoring & Sensor Technology
DDFA	Deactivation and Decommissioning Focus Area
DOE	Department of Energy
DOE-ID	Department of Energy-Idaho Operations Office
EM	Environmental Management
EMCL	Environmental Management Core Laboratories
EMSP	Environmental Management Science Program
ESP	Efficient Separations and Processing
INDP	Industry Programs
INEEL	Idaho National Engineering and Environmental Laboratory
LTS	Long-Term Stewardship
MRS	Monitored Retrievable Storage
NDAA	National Defense Authorization Act
OST	Office of Science and Technology
R&D	Research and Development
RBX	Robotics Crosscutting Program
RCRA	Resource Conservation and Recovery Act
S&T	Science and Technology
SCFA	Subsurface Contaminants Focus Area
STCG	Site Technology Coordination Groups
TFA	Tanks Focus Area
TMFA	Transuranic and Mixed Waste Focus Area
TMS	Technology Management System

LONG TERM STEWARDSHIP TECHNOLOGY PROFILE

1. INTRODUCTION

Based on existing plans and agreements with regulators and affected parties, the cleanup of Department of Energy (DOE) Environmental Management (EM) sites will leave behind residual levels of radioactivity (e.g., buried waste) and other residual hazards at most sites. The challenge facing DOE is to ensure continued protection of human health and the environment after the cleanup projects are complete.

The mission of the Long-Term Stewardship (LTS) National Program is to maintain protection of human health and the environment at the assigned DOE sites (or portions thereof). There are many different perspectives on the definition and scope of long-term stewardship. The definition used for this effort was taken from the National Defense Authorization Act (NDAA) Long-Term Stewardship Report, which states:

> "long-term stewardship refers to all activities necessary to ensure protection of human health and the environment following completion of cleanup, disposal, or stabilization at a site or a portion of a site. Long-term stewardship includes all engineered and institutional controls designed to contain or to prevent exposure to residual contamination an waste, such as surveillance activities, record-keeping activities, inspections, groundwater monitoring, ongoing pump and treat activities, cap repair, maintenance of entombed buildings or facilities, maintenance of other barriers and containment structures, access control, and posting signs."(NDAA Long-Term Stewardship Report, Volume I, DOE/EM-0563, January 2001)

The Idaho National Engineering and Environmental Laboratory (INEEL) is tasked to support the development of the framework and management systems necessary to ensure safe and effective execution of DOE's LTS activities. A major element of this program, under the oversight of the DOE-Idaho Operations Office (DOE-ID), is the development and implementation of improvements to LTS operation and decision making through advances in science and technology (S&T).

A near-term deliverable of the INEEL program is to develop an LTS S&T Roadmap. The roadmap will describe the strategic direction needed for DOE to develop the infrastructure and capabilities necessary to meet its LTS commitments in an efficient manner. The program is establishing a Roadmap Executive Committee to oversee the roadmap to ensure that it is developed from a technically sound, broad-based perspective. The development of the roadmap, by a team of Roadmap Working Groups under the direction of the Roadmap Executive Committee, will identify the LTS needs across the DOE complex, the technologies available to fulfill those needs (using this profile as a starting point), and the gaps where S&T is inadequate in meeting those needs. The identified gaps then define the strategic investments necessary to ensure that the right S&T development efforts occur.

2. PURPOSE AND SCOPE

The purpose of this profiling task was to complete one of the critical steps toward developing the LTS roadmap. To initiate the roadmapping effort, DOE-ID tasked the INEEL with the development of a preliminary S&T profile. This profile of the current S&T activities performed for the DOE Environmental Management Office of Science and Technology (OST) (EM-50) is intended to provide input to the Roadmapping Working Groups to begin the development of the LTS S&T Roadmap. The scope of this task was to identify OST funded S&T activities that are applicable or could potentially be applicable to LTS.

The following OST programs were evaluated as a part of this task:

- Characterization and Monitoring and Sensor Technology (CMST)
- Deactivation and Decommissioning Focus Area (DDFA)
- Efficient Separations and Processing (ESP)
- Environmental Management Science Program (EMSP)
- Industry Programs (INDP)
- Nuclear Materials Focus Area (NMFA)
- Robotics Crosscut (RBX)
- Subcontaminants Focus Area (SCFA)
- Tanks Focus Area (TFA)
- Transuranic and Mixed Waste Focus Area (TMFA)

This report contains three areas of emphasis:

- The methodology employed in the preparation and analysis of the data,
- Results of the analysis and discussion, and
- The conclusions of the review and recommendations made based on the performance of this task.

3. ANALYSIS METHODOLOGY

Information related to OST technology development is maintained in the Technology Management System (TMS) and with Focus Areas, Crosscut Programs, and Site Technology Coordination Groups (STCGs). The TMS is an OST database that is designed to provide access to historical and planning data and information relevant to science and technology needs, technology development, and technology deployment. TMS was the main source of data for the analysis that is documented within this report. Other sources included the individual focus area and STCG data websites.

Although many organizations within DOE and external to DOE develop technology , this study reviewed only OST funded technologies. Since LTS is currently an OST program, the relationship to other OST funded programs is a natural match. Also, most technologies developed within EM are funded from an OST source so the initial profile would be assured of capturing the majority of EM's S&T investments that could be applied to the LTS program. Figure 1 shows the process flow that was employed in this task.

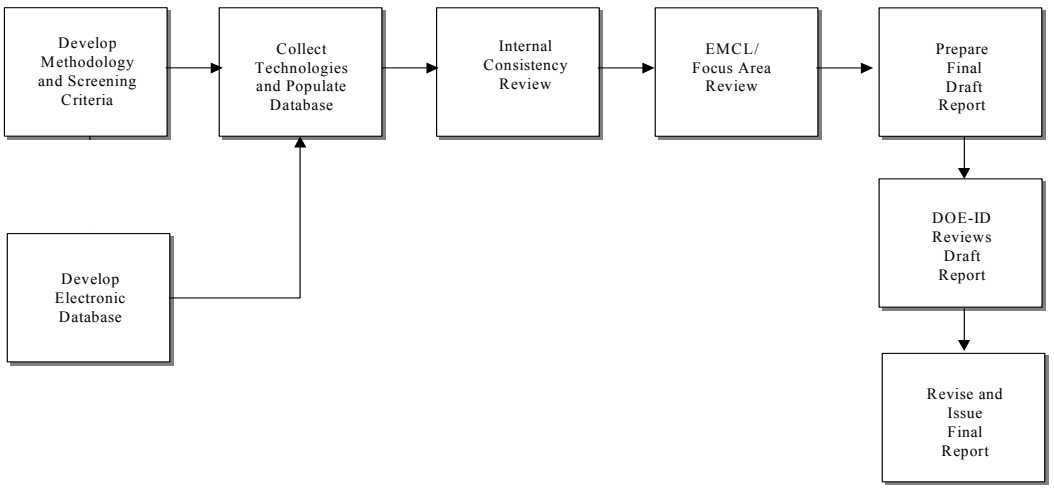

Figure 1. Profiling Process Flow.

Data Management and Technology Screening

Two initial steps, performed in parallel, set the stage for the profiling activities. A Microsoft Access data file was developed to compile the S&T investment data and to enable data management and analysis. A description of the fields included in this Access data file are found in Appendix A.

A set of screening criteria provided a consistent approach to select technologies applicable to LTS. Listed below are the criteria that were used to determine technology applicability to LTS:

Validity –
- Does the technology have the potential to fulfill a likely need within LTS?
- Does the technology have a sound R&D/engineering basis?

Applicability –
- Does the technology relate to one of the LTS functional categories?
- In what stage of development is the technology?

Exclusion –
- Was the technology terminated for poor technical performance?
- Was the technology terminated pre-1997?
- Was the technology terminated at Gate 4 or below?

(Note: Technology development terminated prior to 1997 and/or at Gate 4 or below indicated to the team that it was a low priority activity and/or was not meeting performance expectations.)

(Also, note: OST employs a six R&D gate (also called stages) model ranging from basic research through implementation of a technology. At each gate, specific criteria, requirements and deliverables form a common basis for technology assessment. In the model, the gates are actual decision points, at which projects are evaluated for funding at the next stage. This gate process is meant to provide for evaluation of projects at all stages of development against technical and non-technical criteria. A description of the gates is included in Appendix B.)

Once a decision was made to include a technology in the profile, each technology was assigned to a functional category based on type of technology and the area within LTS that could be supported by the technology. To allow an easy crosswalk between this profile and the previous needs assessment (Long-Term Stewardship, Initial Needs Assessment and Technology Baseline Inventory 2000), the team "binned" the technologies using the same functional categories employed by the needs assessment team. A description of each of the functional categories is included in Appendix C.

The assessment process required that team members use their engineering judgement to determine which functional category the technology would reside under. While some members might place a technology under surveillance and maintenance, another might place the same technology under physical barriers. Since this is an initial effort to understand, at a macro level, those technologies that have a potential to meet an LTS need, inclusion in the profile is the more important concern rather than the specific category where the technology may be applicable.

Reviews

The team met weekly to discuss technology inclusion questions and to ensure that the team members were applying the screening criteria in a consistent manner. The S&T Profile was reviewed by the Environmental Management Core Laboratories (EMCL) and Focus Area Leads to provide an independent quality check. The EMCL was briefed on the profiling task prior to the start of the project so that they were aware of the activity. The EMCL also asked the Focus Areas to determine if strategic planning or roadmapping efforts that focus on LTS were being conducted outside of existing technology development.

The initial external review by the EMCL and Focus Area team leads did not result in changes to the category assignments of the technologies included in the profile. Review by these groups resulted in the addition of only one technology. While the initial input from the EMCL did not identify any major changes to the profile or any strategic planning efforts focused on the area of LTS, is should be noted that this was their preliminary input only. The EMCL had a meeting scheduled for September 12, 2001 to discuss the profile and to develop further detailed review analysis and comments. Due to the unfortunate circumstances that occurred, the meeting was cancelled. The EMCL plans to complete this activity at their next meeting, however, that input will not be available for inclusion in this report. The EMCL input will be provided to the Roadmap Working Groups at a later date.

4. RESULTS AND DISCUSSION OF DATA

The team evaluated 1,027 technologies as shown in Figure 2. The review resulted in the inclusion of 255 technologies that have a potential for use within long- term stewardship.

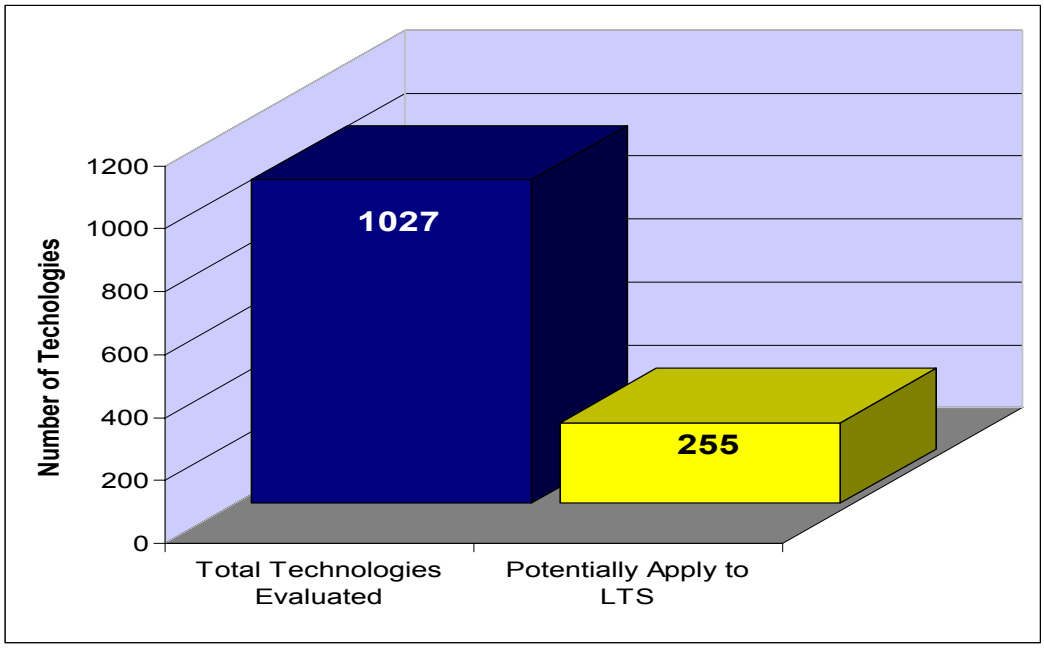

Figure 2. OST technologies applicable to LTS.

The largest technology development efforts applicable to LTS are related to:

- Surveillance and Monitoring (62 percent)
- Sub-Surface Science (16.5 percent)
- Physical Barriers (12 percent)
- Caps and Covers (4.7 percent)

These four categories, as shown in Figure 3, comprise more than 95 percent of the LTS applicable technologies. Since the technologies were developed for the existing cleanup programs and not specifically for LTS, this is as expected. Surveillance and monitoring, subsurface science, and physical barriers are all key areas of concern for the EM cleanup mission.

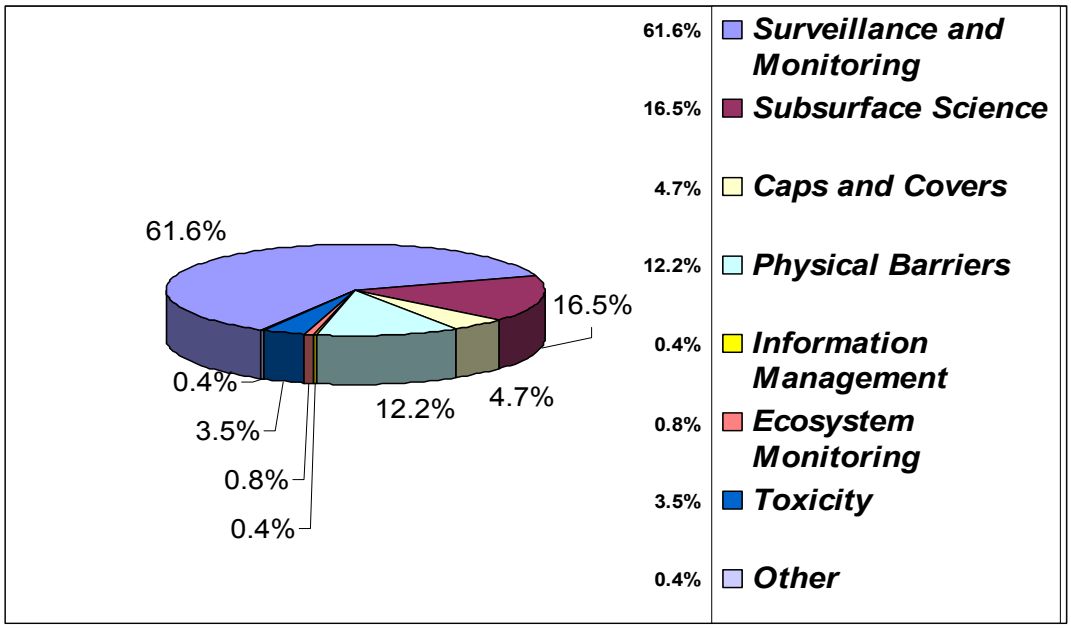

Figure 3. LTS technologies by Functional Category.

As expected, due to the nature of their support to the cleanup mission, over half (53 percent) of the LTS applicable technologies fall under the SCFA and CMST. An additional 28 percent of the total technologies fall under the EMSP. The NMFA did not identify any technologies that appeared to be applicable to the LTS program. A breakdown of the LTS applicable technology development efforts by Focus Area or Crosscut Programs is shown in Figure 4.

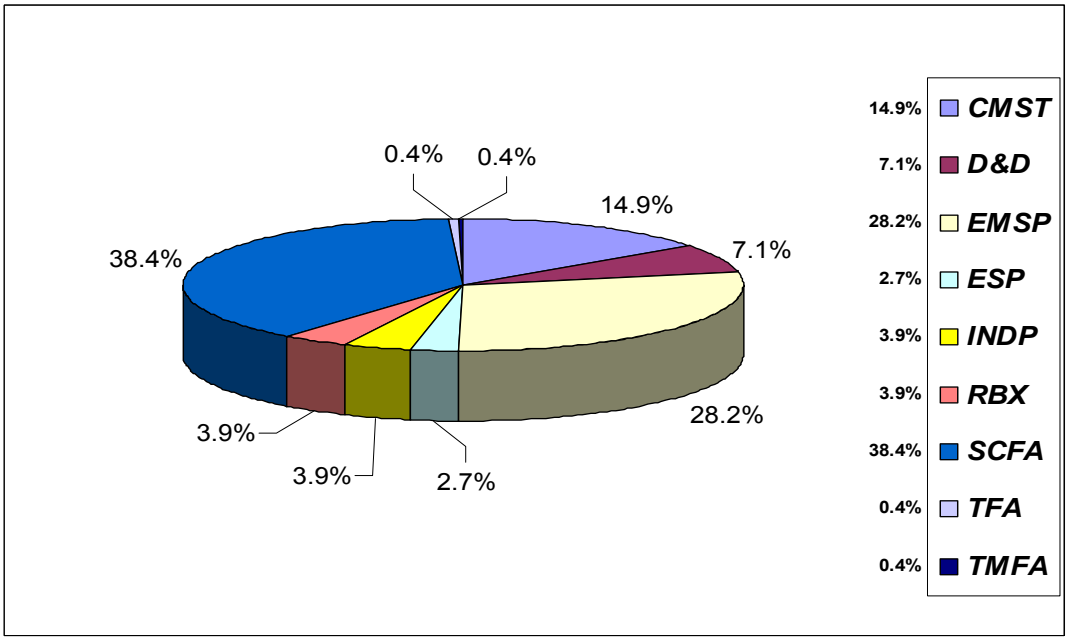

Figure 4. LTS technologies by Focus Area.

The reader may tend to assume that the percentages of technologies listed under subsurface science and the SCFA should be similar. As found by examining Figures 3 and 4, this is not the case. A cross-reference between the focus area technologies and functional category is shown in Table 1. As seen, the focus areas have developed technologies that apply to several categories.

	CMST	D&D	EMSP	ESP	INDP	RBX	SCFA	TFA	TMFA	Subtotal
Surveillance and Monitoring	38	15	22	7	8	10	56	1		157
Subsurface Science			39				3			42
Caps and Covers							12			12
Physical Barriers		2	1		2		25		1	31
Information Management							1			1
Ecosystem Monitoring			1				1			2
Toxicity			9							9
Other		1								1
Subtotal	38	18	72	7	10	10	98	1	1	255

Table 1. Cross-reference Between Focus Area Technologies and Functional Categories.

A breakdown by the functional categories of the needs identified in the FY00 Preliminary LTS Needs Assessment is shown in Figure 5. A comparison between Figures 3 and 5 identifies that the needs and technologies percentages by categories are very similar. This would indicate that OST is investing in the correct areas. One notable difference is the high percentage of subsurface science needs (33% of the total) versus the technologies categorized as subsurface science related (16% of the total). This supports OST's plan to increase its investments in subsurface science.

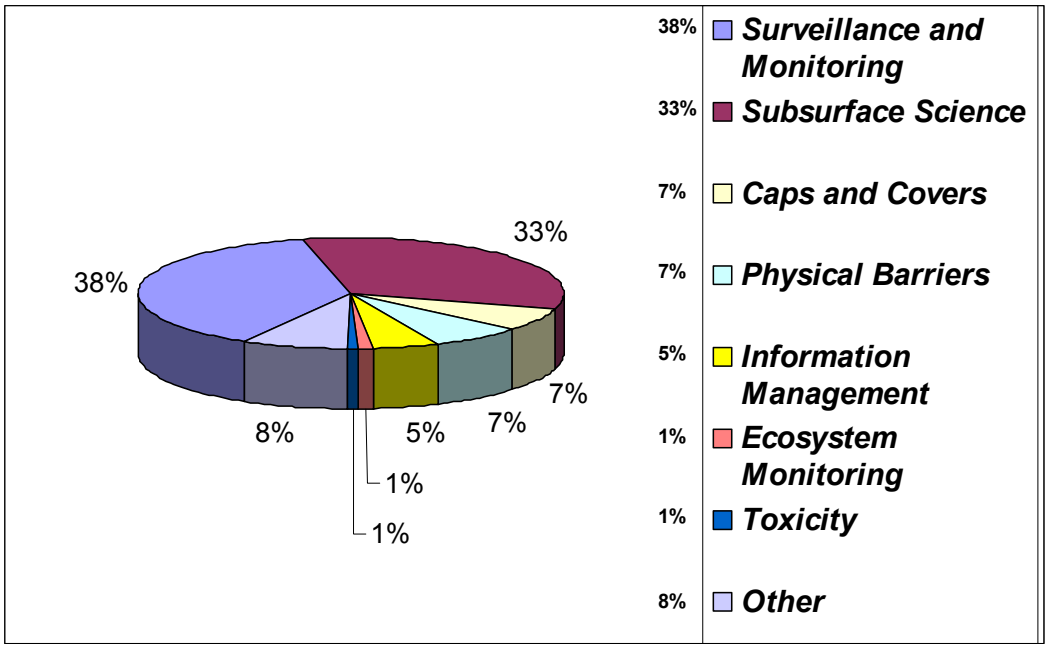

Figure 5. FY00 LTS needs assessment by category.

Throughout this task, the project manager maintained communication with the LTS Roadmapping Team to ensure that the technology profile would provide maximum benefit for use by the Roadmap Working Groups in the development of the LTS S&T Roadmap. It was noted that the Roadmap Working Group activities are planned to be broken out by ten topical areas

rather than the eight categories used by the team. Those topical areas encompass the functional categories used during the profiling task but do not align one-for-one. Additionally, two of the topical areas, Decision Science/Decision Making and Intergenerational Concerns, cover areas outside traditional R&D efforts. No applicable technologies were identified for those topical areas. To simplify use of the profile by the Roadmap Working Groups a cross-reference between the functional categories and the topical areas was developed and found in Appendix D. A breakdown of the 255 technologies by the topical areas is shown in Figure 6. The definitions of the topical areas are included in Appendix E.

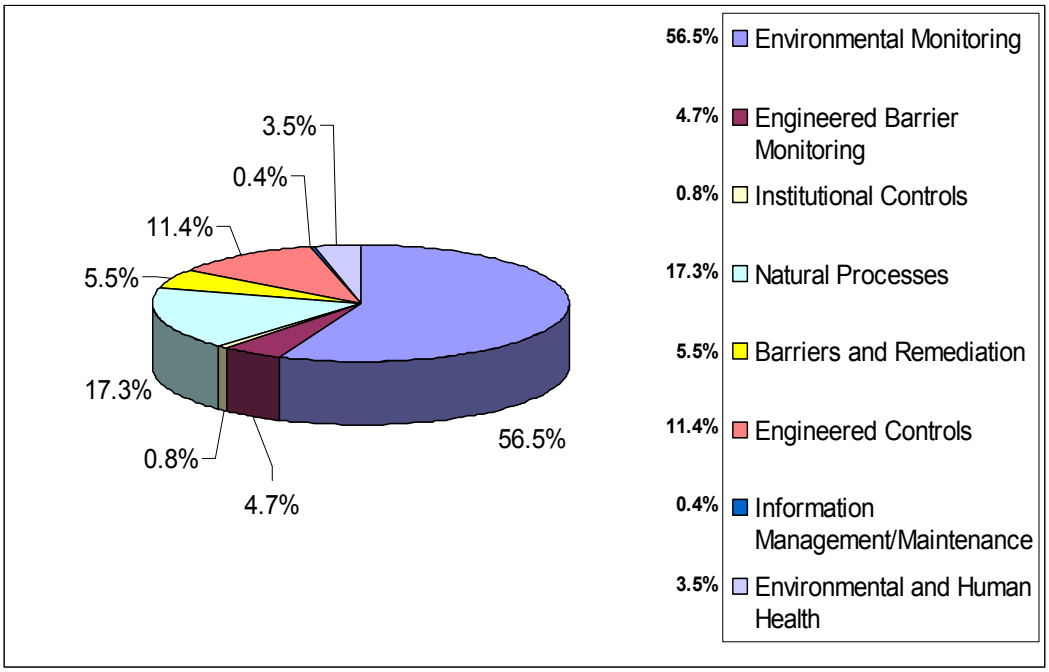

Figure 6. LTS technologies by Topical Areas.

The complete profile set of the 255 technologies is included as Appendix F. Note that if the Roadmap Working Groups desire to have a dataset published by their topical areas rather than the functional categories the system can easily be configured to produce a report in that format.

5. LIMITATIONS

The aim of this report is not to provide an exhaustive listing of all technologies that will meet a long-term stewardship need, but rather to examine EM's major area of investment in technology and identify those technologies that have potential to address a possible, and maybe yet unidentified, long-term stewardship need. In fact, very few if any technology development efforts are underway to specifically address a long-term stewardship need. Users of the data in this report should understand the following limitations of the information:

- The study used only the technology data portion of the TMS as its primary data source. The team accomplished its task without direct discussion with technology developers and this presented challenges when the data in TMS was sparse. In some cases members made a decision for inclusion based only upon the title of a technology. Although the TMS system has fields related to needs and identifies whether those needs are related to LTS, the team did not have access to this portion of the TMS system. Other potential relevant sources, such as Laboratory Directed Research and Development, were not examined but may have also revealed potential LTS technologies

- The team had frequent discussions about what is included under LTS. For example – one definition includes long-term storage as part of LTS – does that mean that something like monitored retrievable storage (MRS) could/should be LTS? If the life of a MRS is 50-100 years, is that any different than a 50-100 year lifetime of a cap or liner? It is likely that the clarity of what is included under a LTS definition will not be complete until the program is more mature.

- The team did not have access to the financial portions of the TMS. Therefore, budget information was only recorded on the profile data sheets where it was noted in the technology data portion of the TMS. If budget information would prove beneficial to the Roadmap Working Groups, it should be relatively simple to obtain by working directly with the Focus Areas and Crosscut Programs.

6. CONCLUSIONS

This study examined the science and technology investments by OST that have potential to satisfy a long-term stewardship technology need. Major conclusions include:

- A significant portion of the science and technology development efforts that have applicability for long term stewardship appear to be occurring within the SFCA, CMST and EMSP areas.

- Although a number of potential technologies may serve a long-term stewardship need, no technologies were specifically identified to address a long term stewardship need.

- The points where environmental restoration, D&D, and entombment ends and stewardship begins is unclear with regards to ownership or technology application.

- This report shows that the Department's subsurface science needs do not have adequate technology development in place to address those needs. This supports OST's plan to increase its investments in that area. the vast majority of the EM related projects and thus those projects that apply to LTS.

- Although some technologies exist or are in development that are applicable to LTS, the current technology profile is inadequate to meet the needs of the LTS program

7. RECOMMENDATIONS

This technology profile is intended to serve as a starting point for the Roadmap Working Groups to begin their efforts. The Roadmap Working Groups need to include significant representation from the operational end-users to ensure that the roadmap maintains a technology "pull" bias based upon need. Additionally, the Roadmap Working Groups need to include representation, at a minimum, from the SCFA, CMST, and EMSP. These key areas are and will be heavily involved in S&T activities directed towards fulfilling LTS needs.

Appendix A

Project Data Definitions

Data collected –

- **Category** – A set of technology bins that the technologies are to be sorted into, which relate to the application of that technology
- **Technology Name** - Name of the technology being cataloged
- **Description** - Brief summary of the characteristics of the technology
- **Expected Capabilities** - Brief summary of the functions that the technology is expected to be able to perform
- **Associated Needs** - Where applicable, document any needs identified that are driving the development of the technology
- **Available Date** - When will the technology be ready for field deployment and use
- **Information Source** – A documentation of all sources that were used in the identification of the various data elements to ensure that the information is reproducible
- **EM-50 Category** - The area of EM-50 that this technology came from
- **Past Investment** - the amount of funding already spent on the development of the technology ($K)
- **Future Investment** - The amount of funding planned to be spent on the development of the technology ($K) in the future
- **Other Information** - Notes and other applicable information associated with the technology
- **Reference ID** – An associated technology ID number (such as a TMS ID)

Appendix B

OST Gate Definitions
Technology Investment Decision Model

Stage 1: Basic Research

In Stage 1, fundamental scientific research for building and documenting core knowledge not tied to a specific defined need is evaluated, with the goal of generating new ideas. Objectives at this stage include identifying a new environmental technology or use of good science. Activities at this stage consist of basic laboratory experimentation, development of theory and analytical models, and proof of principle. The effectiveness of a project at Stage 1 is measured by whether it satisfies a subset of the programmatic driver criteria: specifically, technology and user need; technical merit, cost; and safety, health, environmental protection, and risk.

Stage 2: Applied Research

In the applied research stage, directed scientific or engineering research is conducted that has a link to remediation needs and results in a product concept. The goal is to conduct systems studies to address DOE priority needs. Research conducted includes proof-of-principle and lab-scale experimentation, with the objectives of defining data requirements, preparing experimental designs, determining material requirements, and determining business attributes. Project effectiveness at this stage is measured in terms of whether the project satisfies experimental design plan acceptance criteria and all of the programmatic driver criteria.

Stage 3: Exploratory Development

The goal of the exploratory development stage is to conduct a systems study to address focus area priority needs. The technical feasibility of the project in terms of potential applications is evaluated (i.e., whether the technology can be developed sufficiently to solve the problem), with the objective of verifying that the concept can be linked to specific needs. Project activities at this stage includes laboratory-scale prototyping, analysis of user needs, estimates of life-cycle costs, and identification of functional performance requirements and operational concepts. The effectiveness of the project is measured by whether (1) it continues to satisfy experimental design plan acceptance criteria; (2) experimental performance meets program expectations; and (3) programmatic driver criteria are met.

Stage 4: Advance Development

The goal of Stage 4 is to show a specific DOE application of the product. A proof of design is required, and development includes full-scale laboratory testing, preliminary field testing, technical specification development, and infrastructure development plans. The objectives at this stage are assessment and validation of the technology's specifications and application by a review group. Effectiveness at this stage is measured by whether the application specifications satisfy the external review group's assessment, and whether programmatic driver criteria are met.

Stage 5: Engineering Development

At this stage, knowledge gained from R&D is used to develop systematically a detailed approach for full-scale design. The goal is classification of the technology as likely to exceed DOE baseline or to meet select government performance requirements or a problem set. Objectives at this stage include scaling up and refining detailed designs for prototypes and pilots, and clarifying the DOE deployment strategy and schedules to meet performance needs. This stage of development yields drawings, schematics, and computer codes; construction and demonstration units; prototypes and pilot-scale systems; system evaluation; reliability testing; infrastructure plans; and procurement specifications. Effectiveness is measured by the results of completed and documented preliminary tests, successful test plans, and satisfied programmatic driver criteria.

Stage 6: Demonstration Stage

In Stage 6, the product or technology is subjected to a "real-world" demonstration, either at a DOE site or at another location, using actual waste streams and/or anticipated operating conditions with the goal of verifying design assumptions made up to this point. Objectives include conducting full-scale testing, system testing, and market conditioning to determine system suitability. Effectiveness is measured through programmatic driver criteria and acceptance of the technology by the end user.

Stage 7: Implementation

At Stage 7, the product or technology has been proved to be viable, cost-effective, and applicable to required needs. The technology, if developed by

Appendix C

LTS Functional Categories

1. **Surveillance and Monitoring**

- **Instruments, Sensors, and other Devices**: Development of new instruments or sensors to perform mapping, characterization, monitoring, or surveillance functions directed toward increasing our knowledge and understanding of how contaminants move in the subsurface.
- **Data Collection, Sampling, and Analysis**: Development of surveillance and monitoring devices to improve our ability to sample, collect, analyze, and transmit soil, water, or air-related data.
- **Greater Understanding of Subsurface Science**: Development of improved sensors and monitors to advance science and gain a better understanding of how contaminants reside, interact with, and/or move through below ground environments.
- **Ensuring the Integrity and Longevity of Entombed Facilities**: Development of in-situ monitors, sensors, or surveillance systems to ensure the integrity and long-term performance of facilities (entombed reactors, canyons, processing facilities, and other buildings where residual contamination has been left in place).
- **Ensuring the Integrity and Longevity of Engineered Units**: Development of in-situ monitors, sensors, or surveillance systems to ensure the integrity and long-term performance of engineered units (landfills, caps and covers, and other storage or waste disposal units.
- **Ecosystems**: Development of improved sensors, monitors, and surveillance systems to assess the natural environment surrounding engineered units and entombed facilities to minimize the impacts on human health and the environment.
- **Physical Barriers**: Development of surveillance and monitoring devices for the detection and alarm of human intrusion into hazardous facilities and engineered units.

2. **Subsurface Science**

- **Basic Understanding**: The basic understanding of the physical, chemical, biological, and nuclear processes associated with the fate and transport of contaminants in the subsurface.
- **Modeling**: Physical and computational modeling to predict concentrations of contaminants throughout time.

3. **Caps and Covers**

- **Landfills**: Long-term performance and integrity of landfills.
- **Caps and Covers**: Long-term performance and integrity of caps and covers.
- **Other Units**: Long-term performance and integrity of other storage or waste disposal units configured with engineered controls.

4. **Physical Barriers**
- **Ensuring the Physical Integrity of Waste Forms**: Improved designs and systems to ensure the long-term integrity, sustainability, and performance of waste forms, storage containers, engineered units, and physical barriers.
- **Subsurface Science**: Greater understanding of waste form behavior within the subsurface environment.
- **Physical Barriers**: Development of improved designs, methods, and systems to minimize or eliminate human intrusion into entombed facilities, engineered units, and/or waste disposal and other hazardous areas.

5. **Information Management**
- **Data Collection**: Improved systems for site characterization, baseline inventories, and long-term monitoring and surveillance of contaminants.
- **Data Analysis**: Improved ability to analyze, interpret, present, and retain LTS information.

6. **Ecosystem**
- **Field Data**: Ability to use field data to test model assumptions and to quantify uncertainty around use of biological indicators and numerical modeling results as indices of population and ecosystem changes.
- **Remote Sensing**: Development of remote sensing capability of ecological indicators.

7. **Toxicity**
- **Health Effects**: Determining health effects from contaminants and improved understanding of the toxicity component of risk calculations.
- **Benchmarking**: Development of appropriate toxicological benchmarks and ability to translate benchmarks to higher level impacts.

8. **Other**
- **Other**: Science and technology improvements that do not readily fit one of the other categories. This would include the “soft science” related information such as intergenerational concerns, decision science/decision making, etc.

Appendix D

Functional Categories Cross Reference

LTS Profiling Category	LTS Roadmapping Topical Area
Surveillance and Monitoring (S&M) – Instruments, Sensors, and other Devices	Environmental Monitoring
S&M – Data Collection, Sampling, and Analysis	Environmental Monitoring
S&M – Greater Understanding of Subsurface Science	Environmental Monitoring
S&M – Ensuring the Integrity and Longevity of Entombed Facilities	Engineered Barrier Monitoring
S&M – Ensuring the Integrity and Longevity of Engineered Units	Engineered Barrier Monitoring
S&M – Ecosystems	Environmental Monitoring
S&M – Physical Barriers	Institutional Controls
Subsurface Science – Basic Understanding	Natural Processes
Subsurface Science – Modeling	Natural Processes
Caps and Covers – Landfills	Barriers and Remediation
Caps and Covers – Caps and Covers	Barriers and Remediation
Caps and Covers – Other Units	Barriers and Remediation
Physical Barriers – Ensuring the Physical Integrity of Waste Forms	Engineered Controls
Physical Barriers – Subsurface Science	Engineered Controls
Physical Barriers – Physical Barriers	Barriers and Remediation
Information Management – Data Collection	Information Management/Maintenance
Information Management – Data Analysis	Information Management/Maintenance
Ecosystem – Field Data	Natural Processes
Ecosystem – Remote Sensing	Natural Processes
Toxicity – Health Effects	Environmental and Human Health
Toxicity – Benchmarking	Environmental and Human Health
Other	Various

Appendix E

Topical Area Definitions

Institutional Controls. Stewardship sites, by definition, have some level of residual hazards requiring access restrictions to protect public health. Access restriction methods include physical systems such as warning signs, barriers, and active surveillance, and legal systems such as deed restrictions, easements, and zoning.

This topical area addresses research into effective, economical means to maintain and enforce access restrictions, including both physical and legal systems, across the full range of LTS sites. These include the detection and control of occasional and chronic accidental or deliberate intrusions of the surface and subsurface in urban, suburban, and rural settings.

Environmental Monitoring. LTS workscope includes the monitoring of air, soil, and surface and ground water in general and near engineered barriers to confirm predictions of contaminant fate and detect barrier failures. This will require highly robust and reliable equipment. These systems will need to be remotely accessed by the designated steward (state, tribal or federal) and as such must be user friendly. Environmental monitoring will be needed for all media: air, soil (vadose zone) and water.

This topical area addresses issues associated with long-term environmental monitoring of LTS sites. Issues include the economics, accuracy, reliability, and maintainability of sensors and sampling devices and associated data collection/transmission systems. It also includes the development of systems to collect environmental data in support of research in other topical areas.

Natural Processes. LTS sites will be exposed to natural processes for tens to hundreds of years. This will include both extreme natural events and long-term shifts in climate and other factors that may challenge the design basis or otherwise jeopardize the integrity of engineered systems, resulting in the uncontrolled movement of contaminants through the environment. In addition, current limitations in the understanding of natural processes and cycles such as hydrology and geochemistry impact the accuracy of contaminant fate and transport predictions.

This topical area will address meteorological, as well as geological, hydrological, chemical and biological (GCBH) features, events and processes. Particular emphasis should be on surface and subsurface processes and features to provide a better understanding of bounding requirements for engineered hazard containment systems such as caps and soil vaults and an improved basis for predicting contaminant transport.

Engineered Controls. While some hazardous wastes can be destroyed, many cannot. These include chemical, elemental, and isotopic hazards. Cleanup of these hazards involves stabilization into waste forms that inhibit hazard mobilization, followed

by entombment or disposal in engineered landfills or geologic repositories. Over time, attenuation reduces the remaining hazard through natural processes (chemical breakdown, radioactive decay, etc.). This approach requires continued maintenance, repair, and possible replacement of engineered barriers over extended periods. The majority of waste by volume disposed by the EM cleanup program will be in shallow engineered cells. Caps and barriers are also used to contain residual contamination at cleanup sites and reactive barriers may be used for long-term in situ treatment of groundwater plumes.

This topical area addresses maintenance and repair issues associated with the long-term stewardship of engineered barriers, including caps, liners, grout curtains, reactive walls, massive entombments, and other forms. The area is restricted to shallow barriers and entombed facilities, as significant specialized research directed at geologic repositories is already conducted under other programs.

Engineered Barrier Monitoring. Continuous validation of the health of entombments, caps, and other engineered barriers is needed to allow for early detection of failures and to support research into barrier improvements.

This topical area includes the instruments and systems needed to directly monitor the structural integrity of engineered barriers, including in-situ instruments embedded within the barriers at the time of their construction.

Barriers and Remediation. In the course of passive stewardship, it is expected that monitoring and surveillance will occasionally detect contaminant levels that are higher or lower than predicted. While lower levels are not an immediate concern, higher levels may indicate the need for additional active cleanup such as contaminant immobilization/removal or transport mitigation.

This topical area addresses research into new or improved subsurface barriers and remediation techniques. This includes horizontal and vertical impermeable barriers such as caps and curtains to contain contaminants, in-situ physical, thermal, chemical, and biological treatment methods to immobilize or transform contaminants (e.g. reactive walls, steam injection, in-situ vitrification, chemical or microbial injections, etc.), and extraction and ex-situ treatments to immobilize, transform or separate contaminants. It also includes treatment of contaminants associated with entombments or other massive concrete structures, either above or below the surface.

Environmental and Human Health. Stewardship activities are driven by the need to maintain awareness of and control over hazards that remain above threshold health limits after the completion of active cleanup. The understanding of environmental and human health impacts from low levels of exposure to chemicals and radiation is incomplete, in spite of considerable research to date. For example, many chemicals that are toxic to life at high concentrations appear to be beneficial or even essential at lower concentrations. Given the periods associated with long-term stewardship, significant additional advances in the understanding of health effects should be possible. Improved

understanding will support determinations of when additional active cleanup may be needed as well as when residual hazards have sufficiently attenuated to end stewardship activities at specific sites.

This topical area addresses the environmental impacts and human health effects of low levels of exposure to chemical, elemental, and isotopic contaminants addressed by DOE cleanup activities, includes by-products resulting from chemical breakdown and radioactive decay. Particular focus should be placed on reducing the uncertainty about the health effects of long-term exposure to low levels of radiation and to hazards that do not naturally attenuate, such as toxic elemental metals. The area is extended to include general ecosystem monitoring improvements to support improved understanding of natural versus contaminant-altered communities, populations, and physical/biological cycles.

Intergenerational Concerns. The very long timeframes expected for some stewardship activities have raised a number of intergenerational questions. Disposal of some wastes (such as those that do not naturally attenuate) can be viewed as simply the storage of hazards, deferring their ultimate "destruction" to future generations that may or may not be more advanced and therefore more able to handle them. Every decision for "brownfield" or other incomplete cleanup of land means a restriction on its use by future generations. At the same time, government resources are limited and cleanup expenditures mean less funding for other areas that may have more positive future impacts such as health research or setting aside land for parks or wilderness.

This topical area addresses a broad range of issues concerning the current generation's rights and responsibilities relative to future generations. Economic issues to be addressed include long-term funding methods and more appropriate impact projections than afforded by net-present-value methods. Social issues include societal tradeoffs. This area also involves means of maintaining legal controls and communicating hazard information over multiple generations.

Decision Science/Decision Making. LTS performance requires the analysis and combination of data and information from multiple sources, disciplines, and timeframes to verify the sufficiency of cleanup end states, and engineered and institutional controls. Community values/stakeholder concerns, scientific knowledge, engineering data, economic drivers and other factors all must be considered and balanced. Sound decision making with limited, often conflicting data is always problematic. The negative implications of overly conservative and overly liberal decisions concerning monitoring changes, routine and special maintenance, fielding of new tools and methods, re-remediation, footprint reduction, and ultimately stewardship completion are compounded by the long timeframes of the stewardship program.

This topical area addresses improvements in the ability to make sound decisions in the execution of LTS operations. The area includes efficient decision techniques that incorporate incomplete, conflicting qualitative and quantitative information and data from multiple sources that is periodically updated.

Information Management/Maintenance. Thousands of cubic meters of physical records and terabytes of electronic records exist that document past DOE research and production operations and current waste management and cleanup activities. Additional records will continue to be generated by cleanup and stewardship activities. The maintenance and easy retrieval of information within these records is necessary to support ongoing stewardship activities and address questions concerning past practices, including potential legal challenges addressing worker health and environmental impacts.

This topical area addresses the long-term maintenance and retrieval of records entrusted to the stewardship program, including protection or conversion of both physical and electronic records. Paper records are known to physically degrade while electronic records degrade or simply become unreadable due to obsolescence of data formats. This area also includes the consolidation, indexing, and retrieval of records to support operations and research.

Risk Management. All topical areas will have to address LTS risk issues as part of their respective science and technology assessments.

Appendix F

Technology Profile Data

List of EM-50 Long Term Stewardship Technologies

EM-50 Category: CMST

Techn. Name: Direct Sampling Ion Trap Mass Spectrometry (DSITMS)

Tech #: 51
Ref ID: 69

Date Available:	4/15/1993
Past Investment($K):	1565
Future Investment($K):	0

Surveillance and Monitoring-Data Collection/Samp/Anal

CMST

Description: Direct Sampling Ion Trap Mass Spectrometry (DSITMS) introduces sample materials directly into an ion trap mass spectrometer by means of a very simple interface, such as a capillary restrictor or a polymer membrane, with little if any sample preparation and no chromatographic separation of sample constituents. Target analytes include Volatile Organic Constituents (VOCs) and selected SemiVolatile Organic Constituents (SVOCs). Instrument analysis is nearly instantaneous; analyses are typically completed in less than five minutes at cost typically less than half that of standard EPA Method analyses performed in commercial laboratories. DSITMS can be used in conjunction with Cone Penetrometer sampling methods.

Expected Capabilities: DSITMS is particularly useful for field screening where the presence or absence of a broad range of VOCs is of concern, as well as for monitoring remediation efforts where prior information on the identity of contaminants of concern is available. It can significantly reduce the cost and delay associated with off-site laboratory VOC and SVOC analyses of groundwater and soil gas samples, allowing for near-real-time decisions on locations of subsequent samples. The low detection limits, comparable with those of EPA´s Method 8260 (GC/MS) for VOCs, ensure reliable decisions regarding absence of VOCs.

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 69

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents would likely have applicability.

Techn. Name: **BetaScint Fiber-Optic Sensor for Detecting Strontium-90 and Uranium-238 in Soil**

Tech #: 52

Ref ID: 70

Date Available:	12/31/1994
Past Investment($K):	575

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K):	0

CMST

Description: The BetaScint(TM) sensor is designed to measure beta emissions from Sr-90 and U-238 in soils. The sensor is 150x35x8cm; it can measure contamination of the soil surface or of a soil sample spread over a tray. The time required is 20 minutes per sample at a cost of $30-55, compared with 1-4 weeks and $150-275 for laboratory analyses. The BetaScint sensor works as follows: (1) beta particles (electrons) emitted by radioactive soil contaminants excite electrons in fluorescent compounds doped into plastic fibers in the layers of the sensor; (2) these give off light (scintillate) when the fluorescent molecules lose energy and return to their ground state; (3) scintillations are counted by photodetectors to determine beta radioactivity of the soil sample. Sample processing is limited to drying and sieving soil samples to remove rocks and excessive organic matter. The BetaScint system is easy to operate and does not generate secondary wastes.

Expected Capabilities: Rapid and relatively inexpensive Sr-90 surveys of large areas allow real-time monitoring of remediation progress and excavation planning, potentially reducing the overall cost of analyses and avoiding costs by not excavating soils unnecessarily, and also avoiding secondary waste generation.

Sources: TMS
TSS [Title]:Summary Sheet #1 for Tech ID 70

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides would likely have applicability.

Techn. Name: Chemical Analysis Automation

Tech #: 53	**Date Available:**	9/30/1998	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 72	**Past Investment($K):**	19275	**Future Investment($K):**	0	**CMST**

Description: The purpose of DOE´s CAA Project is to develop a flexible, plug-and-play approach to automating regulatory compliant, chemical analysis procedures to benefit DOE´s environmental management activities. Over the past seven years, the CAA project developed most of the elements essential to such an automated analysis system. The program´s initial focus was the organic constituents identified in the Resource Conservation and Recovery Act (RCRA) and related regulations. In addition, work has begun on a CAA system for analysis of the metals designated as RCRA hazardous. Finally, DOE´s large, high-level mixed waste problems represent an area that CAA can likely impact.

Expected Capabilities: The CAA project is developing a standardized modular automation strategy for chemical analysis. In this automation concept, analytical chemistry is performed with modular building blocks that correspond to individual elements of the steps in the analytical process. This modularity permits the end user to utilize existing EPA-approved methodologies, while providing for the integration of newer, cutting edge methods yet to be developed. The fundamental building block for CAA is a software system capable of managing a wide array of user-specified analyses.

Sources: TMS
TSS [Title]: CHEMICAL ANALYSIS AUTOMATION PROJECT

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to automate analysis of hazardous constituents would likely have applicability.

Techn. Name: Secondary Ion-Mass Spectroscopy Analysis: Development and Evaluation

Tech #: 55

Ref ID: 135

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K): 0

CMST

Description: Fast, inexpensive, and nonpolluting instrumentation for the detection of surface contaminants is being developed at the INEEL using advanced Secondary Ion Mass Spectroscopy (SIMS) technology. The attributes of this technology make it extremely attractive for waste and environmental characterization: No sample preparation is required. No waste is generated. Analysis is rapid and simple. It is capable of speciation, fingerprinting. The technology is amenable to almost any sample type. It is amenable to involatile organics, salts. SIMS has a simple principle of operation: surfaces are bombarded with high-energy particles that sputter the contaminants into the gas-phase, where they can be detected as ions. The objective of the SIMS analysis program is to develop instrumentation and chemical applications for: (1) detection of chemical species; and (2) identification of semivolatile, involatile, or adsorbed contaminants on the surfaces of soils, minerals, salts, rocks, and other difficult-to-handle sample types. During the course of the SIMS Analysis program, detection applications and instrument development were accomplished. In FY96, the objective of the program is to transfer technology to end users and to instrument manufacturers.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Transferred to user or industry to complete the development. No date given for completion. This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides and hazardous constituents could have applicability.

Techn. Name: Time Domain Reflectrometry (TDR) and Fiber-Optic Probes for the Cone Penetrometer

Tech #: 56 | **Date Available:** | Surveillance and Monitoring-Data Collection/Samp/Anal

Ref ID: 141 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **CMST**

Description: A TDR system for measuring moisture content and a fiber-optic probe for measuring pore pressure near the tip of a cone penetrometer have been developed. A cone penetrometer truck uses hydraulic pressure to push a hollow rod through unconsolidated soils to depths as much as 200 feet to characterize subsurface soil properties and to collect soil and groundwater samples.

Expected Capabilities: Devices that measure moisture in the subsurface and the groundwater level exist for wells and boreholes but have not been available on a cone penetrometer truck. Rapid determination of groundwater level on sites with few wells or boreholes, can speed up site characterization efforts.

Sources: TMS

Notes/ Other Info: Transferred to user or industry to complete. No date given for completion. This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides and hazardous constituents could have applicability.

Techn. Name: In Situ Measurement of Volatile and Semi-Volatile Organic Compounds in the Subsurface

Tech #: 61 | **Date Available:** | Surveillance and Monitoring-Data Collection/Samp/Anal

Ref ID: 219 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **CMST**

Description: The overall goal of this investigation is to develop methods and technology that will couple a CPT with field-deployable gas chromatography/mass spec-trometry (GC/MS) instrumentation to transfer VOCs and SVOCs from subsur-face material at depth to the analytical instrument in the field. Sampling, preconcentration, and analytical equipment will be directly coupled to a CPT to provide on-line, near-real-time analyses for VOCs (e.g., trichloroethylene, benzene) and SVOCs (e.g., polynuclear aromatic hydrocarbons, polychlori-nated biphenyls) in subsurface materials. Preconcentration devices will be interfaced to GC/MS instrumentation and coupled to sampling devices housed in a CPT for in situ quantitative measurement of VOCs in soil gas and groundwater, and for screening of VOC and SVOC levels in the soil external to the penetrometer wall. The VOCs and SVOCs liberated from subsurface material will be carried to the surface by an inert, heated transfer line, preconcentrated, and analyzed by thermal desorption GC/MS.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: This technology is on hold, pending a decision to proceed. It appears to be nearing the completion stage. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: **Miniature Pumps in the Cone Penetrometer Tip for Groundwater and Soil Sampling (Cone Sipper)**

Tech #: 68

Ref ID: 381

Date Available:

Past Investment($K): 162

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K): 0

CMST

Description: The Cone Sipper is a groundwater and soil vapor sampling device designed to be used with a cone penetrometer truck (CPT). The probe is advanced into the subsurface with the CPT for and can be used to collect samples at multiple depths in a single borehole. Samples are brought to the surface via small-diameter plastic tubes and the device can be purged for reuse in situ by injecting distilled water, air, or inert gas. The main advantage of the Cone Sipper over other groundwater samplers is that it eliminates the need for retrieval and decontamination of the sampler between sampling intervals. Its simple construction, using just three remote-controlled valves, ensures reliable operation.

Expected Capabilities: Cost-effective depth penetration capability for subsurface sampling and probing. Significantly less invasive than drilling. No waste cuttings to bring contaminants to the surface. Real-time analysis capability for some organic and radionuclide contamination during push operation.

Sources: TMS
TSS [Title]: Miniature Pumps in the Cone Penetrometer Tip for Groundwater and Soil Sampling (Cone Sipper)

Notes/ Other Info: Transferred to user or industry to complete the development. Completed, but no date given. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Sol-Gel Indicator Program

Tech #: 70

Ref ID: 384

Date Available: 12/31/1997

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Data Collection/Samp/Anal

CMST

Description: Using sol-gel indicator (SGI) composites, develop sensor elements to measure pH, uranium, mercury, and selected halogenated organic compounds. Sol-gel indicator (SGI) composites are being used by the Savannah River Technology Center to manufacture sensor elements to measure environmentally important species and conditions. The technology is based on incorporation of indicator materials into specially prepared porous silica, alumina, or titania glass matrices. The SGIs change color in response to analyte concentration. Sensors are prepared by coating SGI composites on optical components so that photometric measurements can be made. Currently, an SGI sensor for uranium is being integrated into an analytical measuring system. Work is underway to identify a new target heavy metal and an organic contaminant for sensor development.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Transferred to user or industry to complete the development. Says it was not completed, but that it is commercially available?! This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive and hazardous constituents could have applicability.

Techn. Name: RCRA Metals Analysis by Laser-Induced Breakdown Spectroscopy

Tech #: 75

Ref ID: 434

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K): 0

CMST

Description: This project is developing a field-deployable instrument for rapid determination of hazardous metals in soils at hazardous and mixed waste sites. The data quality is expected to be suitable for use of the instrumentation as a field analytical method during site characterization. Elements specifically targeted are those of primary concern at the Component Development Integration Facility (CDIF) in Butte, MT. Primary analytes of interest at this facility are As, Pb, Cd, Cu, and Zn. In addition, Ag, Cr, Fe, and Mn are also of interest due to regulatory drivers. The instrumentation will be based on laser-induced breakdown spectroscopy (LIBS). Using LIBS, it will be possible to determine rapidly both the concentration and location of elemental species at a waste site. In LIBS, laser light is focused on a surface to vaporize a small amount of material. The vaporized material forms a short-lived plasma, which emits light that is collected, dispersed and analyzed. LIBS instrumentation can be made quite compact and only requires line-of-sight access to a material. The method thereby lends itself to integration with other instruments and several instrument configurations. The working head of one portable instrument constructed at LANL is four inches in diameter and eight inches in length. Using a fiber optic cable to guide the laser energy to soil will decrease the size requirements. Also, stand-off analyses of at least fifty feet are anticipated to be achievable. The final form of the prototype instrumentation will be designed to target the instrument configuration needs and data requirements of the CDIF. A prototype instrument that will be capable of detecting many of the above mentioned elements is scheduled for delivery to the CDIF at the end of FY95.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Transferred to user or industry to complete the development. No date given for completion. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: HeavyWeight Cone Penetrometer

Tech #: 76 | **Date Available:** 12/31/1992 | Surveillance and Monitoring-Data Collection/Samp/Anal

Ref ID: 489 | **Past Investment($K):** 357 | **Future Investment($K):** 0 | **CMST**

Description: The cone penetrometer is a truck-mounted device that rapidly penetrates into the ground to collect characterization data. The device has been geotechnically applied for approximately 50 years, but is relatively new for environmental restoration. The cone penetrometer rod has a conical tip of up to 1.75 inches in diameter. It pushes hydraulically into the ground with pressures up to 70,000 pounds. The hole generated by the cone penetrometer retains the outside diameter of the rod and can be grouted for ground-water protection, preventing the escape of contaminants as the probe is withdrawn. For soil characterization, as the rod progresses into the ground, a computer reads data from sensors located in both the tip and the side of the probe. The cone penetrometer can monitor for contaminants as the probe is advanced. It can leave screens in place as the rod is withdrawn. The cone penetrometer can advance through fine-grained soil at a rate of 40 to 50 feet an hour. This tool has been adapted for use in the gravel/cobble subsurface common to arid sites. At this time the reliability of the cone penetrometer varies with soil type. When used in gravel, the cone penetrometer remains approximately 90% reliability (minimal refusal) with two attemps in gravels to depths of 50 feet. In gravels to 100 feet, the percentage drops to approximately 50-75%. In soft soil, the cone penetrometer remains near 100% reliability. The heavy-weight cone penetrometer system has been successfully deployed and demonstrated at numerous DOE sites as well as at Fairchild Air Force Base in Spokane, Washington. Cone penetrometers can be designed to1collect several types of data in addition to collecting ground-water samples. The cone penetrometer is currently being transferred to the Environmental Restoration program at the Hanford site.

Expected Capabilities:

Sources: TMS
TSS [Title]: HeavyWeight Cone Penetrometer

Notes/ Other Info: Commercially available in 1996. Transferred to user or industry to complete the development. This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive and hazardous constituents could have applicability.

Techn. Name: Field-Deployable VOC Analyzer

Tech #: 79

Ref ID: 711

Date Available: 12/31/1997

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Data Collection/Samp/Anal

CMST

Description: Development of advanced technologies with real-time, on-site capabilities has been focused on detecting VOCs; this focus was caused by the potentially significant impact of use of such technologies because of the prevalent nature of VOC contamination in groundwater and soil at DOE sites as well as the many Records of Decision requiring their timely removal. The theme of bringing laboratory analysis capabilities to the field is central to the practice of ESC. Field analysis technologies used during ESC incorporate detection principles based on mass spectrometry, infrared absorption, and acoustic wave methods.

Expected Capabilities: On-site analysis and real-time capability of some tools to significantly reduce analysis cost and turnaround time. avoidance of artifacts associated with sample transport for offsite analysis. timely availability of data to allow use of a smart strategy to determine where and when to sample.

Sources: TMS

Notes/ Other Info: Commercially available, but not implemented. Transferred to user or industry to complete the development. This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive and hazardous constituents could have applicability.

Techn. Name: Rapid Sampling Using 3M Membrane Technology

Tech #: 82	**Date Available:**	12/31/1997	Surveillance and Monitoring-Data Collection/Samp/Anal	
Ref ID: 1514	**Past Investment($K):**	562	**Future Investment($K):** 0	**CMST**

Description: Since 1989, Minnesota Mining and Manufacturing Co. (3M) has incorporated state-of-the-art solid-phase extraction (SPE) technology into commercial membrane products for analytical sample preparation. 3M Empore™ High Performance Extraction Disks have become the SPE industry standard for meeting or exceeding U. S. Environmental Protection Agency (EPA) requirements for water analysis.
Recently disks have been introduced to capture and analyze radionuclides as well, including cesium-137, strontium-90, radium-226, and technetium-99. These Rad Disks utilize various classes of adsorbing particles loaded into a membrane, greatly simplifying and economizing radiometric sampling and analysis. Traditional sample preparation steps-such as lengthy precipitations, column extractions/elutions, and related pre-concentration processes are eliminated, as is the need to transport bulky liquid samples. Furthermore, once the Rad Disks are loaded, they are placed directly onto planchets or into liquid-scintillation vials for radiometric counting.
To adapt these disks to field use, they are available in Rapid Liquid Sampler (RLS) form, which is a rugged, color-coded, disposable plastic holder. The RLS readily adapts Rad Disks to commercially available field-use devices, such as the Isco field sampler and 3M attended field sampler. Currently, 3M is evaluating the potential of commercially available portable counting instruments for direct Rad Disk field analysis. Although this project is focused upon furthering analytical applications, 3M is also addressing large-scale remediation efforts through a similar technology for other U. S. Department of Energy (DOE) customers.

Expected Capabilities: DOE can expect to realize the following benefits based on the successful implementation of the RLS/field sampler: Rapid Deployment of New Technologies in the Form of User-Friendly Systems ? Increased productivity through higher sample throughput. ? Greatly improved sample turnaround–from weeks to days or hours, by virtually eliminating sample preparation steps. ? Increased analytical accuracy and precision. ? Efficient sampling (greater than 95 percent of analyte retained). ? Minimization of analytical interferences through selective analyte capture. ? Convenient achievement of lower detection limits. ? Reduced costs in sample handling and analyses. ? Field-readiness: RLS/fieldsampler is rugged, compact, and battery-powered.

Sources: TMS
TSS [Title]: Rapid Sampling Using 3M Membrane Technology

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive constituents could have applicability.

Techn. Name: **Penetration Enhancement for the Cone Penetrometer Using Sonic Drilling Technology**

Tech #: 83	**Date Available:**	12/31/1999	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 1686	**Past Investment($K):**	650	**Future Investment($K):**	0	**CMST**

Description: The sonic enhancement to the Cone Penetrometer Technology (CPT) greatly enhances the penetration capability in unconsolidated soils allowing CPT to be used in more difficult soils for site characterization and monitor emplacement. CPT coupled with a sonic drive allows advancement of CPT probes through layers in which CPTs have previously encountered refusal (e.g., 120 ft depth at SRS M-basin, gravel layers at Hanford). Combining vibratory and hydraulic push methods, the integrated sonic CPT system will have static and dynamic push capacities of 30,000 lb. at 35-150 Hz. The enhanced penetration capability allows existing CPT trucks to be as effective as heavy weight trucks.

Expected Capabilities:

Sources: TMS
TSS [Title]: Sonic-enhanced Cone Penetrometer Testing (CPT)

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents may have applicability.

Techn. Name: LASMA

Tech #: 85
Ref ID: 2074

Date Available:		Surveillance and Monitoring-Data Collection/Samp/Anal	
Past Investment($K):	160	**Future Investment($K):**	0

CMST

Description: The Laser Ablation Source Mass Analyzer (LASMA) is a small, field-portable unit for the rapid screening and analysis of solid and liquid samples using laser ablation techniques.
This module is a rapid turnaround screening module applicable for both organic and metal analysis applications. The LASMA will provide a field and laboratory capability for the detection of isotopes and the measurement of isotope ratios. It provides resolution comparable to that of much larger instruments currently in use. It is capable of parts-per-million detection of elements. The use of LASMA requires little or no sample preparation. The unit is easily transported to field sites, requires only standard electrical power, and weighs less than 75 kilograms.
LASMA is operated by focusing a Nd YAG laser (power density approximately 109 W/cm2) on the sample surface, where it evaporates and ionizes the material. The ions that are produced are directed to the time-of-flight (TOF) mass spectrometer. The instrument includes the following components: • Nd YAG laser with a power supply and focusing lens • Sample illumination and observation system that uses the sample optics as the laser • Feed system for the introduction of samples capable of handling solids or liquids • TOF mass spectrometer 24 cm long, with a diameter of only 10 cm, containing a 4-cm reflector • Four metal rings used as electrostatic lenses and a three-grid section to select ions with energies lower than a specified limit • Detector consisting of two microchannel plates.

Expected Capabilities: The benefits of the LASMA module include: • Field portability • Minimum utility requirements for operation (standard electrical power) • Rapid sample screening in the field or in the laboratory • Capable of isotopic determinations • Little to no sample preparation required for analysis

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 2074

Notes/ Other Info: No date for completion was given. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Ribbon NAPL Sampler

Tech #: 89

Ref ID: 2238

Date Available:	7/31/2001
Past Investment($K):	50

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K):	0

CMST

Description: The FLUTE Hydrophobic Flexible Membrane is a sampling device that provides detailed delineation of Dense Nonaqueous Phase Liquids (DNAPL) in a borehole. It is deployed via a reusable nylon liner, with a hydrophobic ribbon impregnated with dye, that when everted into a borehole creates a tight contact with the walls of the borehole. When deployed, the ribbon will absorb the DNAPL that is in contact with the membrane causing a color change in the dye. Upon removal, the membrane is turned inside out and the ribbon is retrieved into the membrane. The ribbon is then removed and examined. The presence of DNAPL is indicated by brilliant red marks on the hydrophobic ribbon. Sections of ribbon can also be sent for laboratory analysis to identify the specific NAPL compounds that are present.

Expected Capabilities: The Ribbon NAPL Sampler provides rapid in-situ location of NAPLs (Non-Aqueous Phase Liquids) in the subsurface, allowing for quick, inexpensive delineation of the presence and extent of contamination. When deployed via existing boreholes or holes made by direct push systems, no secondary wastes are generated. Analysis of samples (of the membrane) is required only to further identify the NAPLs found.

Sources: TMS
TSS [Title]: FLUTe System for Cone Penetrometer

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Precision Injection / Extraction Probe

Tech #: 90

Ref ID: 2239

Date Available:

Past Investment($K): 60

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K): 0

CMST

Description: The cone penetrometer is a heavy-weight truck with a hydraulic push system that is used for subsurface site characterization. In the standard configuration, the tip of the cone penetrometer rod is equipped with sensors that measure depth-discrete physical and geologic parameters of the subsurface. Detection instruments and sampling devices for water, gas, and soil have been modified and housed within the cone penetrometer rods to provide detailed contaminant information. The Precision Injection/Extraction (PIX) DNAPL characterization method will indicate the presence or absence of depth discrete DNAPL by using CPT technology. Small known volumes of DNAPL solubilizing fluids are injected and extracted through the cone penetrometer using a Cone Sipper probe. The extracted fluid can then be analyzed for DNAPL components.

Expected Capabilities:

Sources: TMS
TSS [Title]: Precision Injection/Extraction Probe

Notes/ Other Info: No date for completion was given. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Surface Acoustic Wave Array Detectors

Tech #: 49	**Date Available:**	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 16	**Past Investment($K):** 0	**Future Investment($K):** 0	**CMST**	

Description: The Surface Acoustic Wave Array Detectors technology employs one or more acoustic wave sensors using sorbent coatings to measure chlorinated hydrocarbons and other volatile organic compounds (VOCs).
Development of advanced technologies with real-time, on-site capabilities has been focused on detecting VOCs; this focus was caused by the potentially significant impact of use of such technologies because of the prevalent nature of VOC contamination in groundwater and soil at DOE sites as well as the many Records of Decision requiring their timely removal.

Expected Capabilities: On-site analysis and real-time capability of some tools to significantly reduce analysis cost and turnaround time. avoidance of artifacts associated with sample transport for offsite analysis. timely availability of data to allow use of a smart. strategy to determine where and when to sample.

Sources: TMS

Notes/ Other Info: Commercial sources can supply at least part of the technology now. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazarouds constituents would likely have applicability.

Techn. Name: Electrical Resistance Tomography for Subsurface Imaging

Tech #: 50	**Date Available:**	10/1/1997	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 17	**Past Investment($K):**	410	**Future Investment($K):**	0	**CMST**

Description: Electrical Resistance Tomography (ERT) noninvasively maps in 3-D the subsurface. It can be used on a scale from feet to kilometers. ERT has been applied to mapping subsurface hydrogeological features and provides good resolution mapping of confining layers of various types. ERT has also been successfully demonstrated for real-time imaging of remediation processes to provide process control. Remediation processes imaged include: soil heating, pump and treat, steam injection, electrokinetics, Dynamic Stripping, Hydrous Pyrolysis and more. ERT has been successfully engineered to allow rapid and inexpensive installation of electrodes with a Cone Penetrometer. The technology for site characterization and remediation monitoring has been commercialized and has been deployed at DOE and commercial sites.

Expected Capabilities: Electrical Resistance Tomography can image in real time processes in the subsurface such as groundwater pumping, soil heating, steam injection and simple geological features such as clay lenses and aquitards.

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 17

Notes/ Other Info: Technology is being used by DOE sites. This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides and hazardous constituents would likely have applicability.

Techn. Name: **Remotely Piloted Vehicles (RPVs) and Miniaturized Sensors**

Tech #: 54 | **Date Available:** 12/31/1995 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 76 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **CMST**

Description: Remote Sensing techniques, such as aerial photography, multispectral scanning, and airborne geophysics, are of unquestioned value of hazardous waste site characterization, facility monitoring, and clean-up verification. But remote sensing is often dismissed as too expensive unless the waste site is large enough to justify the system mobilization and data processing costs. The goal is to demonstrate that for small sites, a radio-controlled airplane or helicopter can be used to collect the high-quality data quickly and cheaply. For example, when new buildings or roads are constructed at an active disposal site, existing aerial photographs become dated, making it more difficult for the facility manager to plan further work. But by using a small, radio-controlled airplane, equipped with an ordinary 35 mm camera and a video viewfinder, a new aerial photograph of the site can be taken immediately, eliminating the cost and inconvenience of hiring a helicopter or fixed-wing aircraft. With minimal effort, a whole series of aerial photographs could be taken to document activities at the burial ground. Task efforts are not limited to photography. A new generation of lightweight, low-power sensors is being developed by the Office of Science and Technology, including magnetometers and electromagnetic sensors. These new sensors offer exciting new applications for airborne miniature platforms.

Expected Capabilities: Facility monitoring

Sources: TMS

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides and hazardous constituents could have applicability.

Techn. Name: **Miniaturized Chemical Flow Probe Sensor Development**

Tech #: 60

Ref ID: 218

Date Available:	12/31/1996
Past Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	0

CMST

Description: The FlowProbe(TM) Chemical Analyzer is a small, portable, chemical analyzer that measures chemicals in both liquid and gaseous states. This technology can be used wherever reagent-based chemistry exists that provides analyte concentration information detectable by optical absorption spectroscopy. The FlowProbe(TM) Chemical Analyzer was designed to be an in situ generic platform for performing wet chemistry-based analyses in field survey, process control, and monitoring applications. It has been packaged both as a bench-top instrument and a down-hole unit. Both configurations can perform up to 500 analyses before the reagent must be replenished. Initially there were two classes of compounds that the FlowProbe(TM) Chemical Analyzer was targeting: metals and chlorinated organic compounds. All chemistries and sensor materials are compatible with the measurement of analytes in aqueous matrices.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Transferred to user or industry to complete. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Neural Network Raman Cone Penetrometer Signal Extraction and Enhancement

Tech #: 63	**Date Available:**		Surveillance and Monitoring-Instruments/Sensors/Devices	
Ref ID: 242	**Past Investment($K):**	620	**Future Investment($K):** 0	**CMST**

Description: The cone penetrometer is a truck-mounted, ground-penetration device that can be equipped with tools for sampling soil and groundwater and with instruments to monitor contaminants and geophysical data. It has been used as a cost-effective sampling tool at many DOE sites. Advanced sensors and instruments deployed by the cone penetrometer are being applied for delineation of subsurface radiological and chemical contaminant plumes, probing of the ground environment for better selection of locations fo installation of monitoring wells, and improved placement of monitoring devices in the subsurface. This task is to develop a hybrid neural network (NN) system for real-time data and analysis of chemical constituents in underground storage tanks (UST). This is coupled with an advanced LLNL fiber optic Raman spectroscopic probe for in situ cone penetrometer deployment.

Expected Capabilities: Minimizes extractive sampling; provides data for safe operations and remediation.

Sources: TMS
TSS [Title]: Cone Penetrometer Raman Probe

Notes/ Other Info: Transferred to user or industry to complete the development. No date given for completion. This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides and hazardous constituents could have applicability.

Techn. Name: **Cone Penetrometer Support: Operation, Maintenance, and R&D Activity Conducted on the OTD Cone Penetrometer Vehicle**

Tech #: 64

Ref ID: 243

Date Available:	12/31/1999
Past Investment($K):	4180
Future Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

CMST

Description: For many characterization activities, cone penetrometer techniques are favored over conventional drilling activities due to cost, schedule, or safety issues. The U. S. Department of Energy (DOE) Site Characterization and Analysis Penetrometer System (SCAPS) truck is currently located at the Savannah River Site (SRS) and is used primarily for the evaluation and demonstration of innovative Cone Penetrometer Test (CPT) sensors. In order to receive end-user or regulatory acceptance, new technologies, especially those that address difficult characterization problems, often require systematic testing under progressively more challenging conditions. Field-testing is the only way to test the robustness of technologies in a variety of hydrogeologic settings and to develop reliable, comparative unit cost and performance data. The main purpose of the activities funded currently under this task is to extend the capability of CPT truck-based systems for direct, in situ detection of Dense Non-Aqueous Phase liquids (DNAPLs). During the last 18 months, we have evaluated multiple sensors and have developed a DNAPL characterization toolbox that provides a relatively robust system for the in situ detection of DNAPLs in real time,. The technologies are evaluated and implemented at Environmental Restoration Waste sites and the results are used to address real characterization needs.

Expected Capabilities: The use of the SCAPS truck for environmental characterization and monitoring is favored over baseline drilling and sampling because in many situations, this CPT system can: ? Provide continuous, real-time, subsurface information to aid in site characterization operations as they progress. ? Minimize disturbance to the subsurface as no drilling fluids are used and the push-hole diameters are quite small (approximately 1 to 2 inches in diameter). ? Cost considerably less than conventional drilling and sample analysis methods. ? Offer the advantage of real-time data analysis so that the push location can be selected based on the results of holes already pushed. ? Can be used with sensors to measure various types of chemical contaminants and other physical characteristics of the subsurface. ? Are safer than conventional drilling because worker exposure is minimized due to faster subsurface access and the minimal amounts of waste generated. ? Makes possible the rapid and cost-effective definition of contaminant plumes thus enabling more accurate placement of remediation systems and monitoring wells.

Sources: TMS
TSS [Title]: DOE-owned Cone Penetrometer Truck (CPT) and CPT Sensor Testing and Deployment Project

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents may have applicability.

Techn. Name: Cone Permeameter

Tech #: 66 | **Date Available:** 9/1/1998 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 307 | **Past Investment($K):** 368 | **Future Investment($K):** 0 | **CMST**

Description: The Cone PermeameterTM rod incorporates a proven fluid injection design and highly accurate pressure sensing elements embedded in the rod. The design allows the permeability meter measurements to be conducted simultaneously with standard Cone Penetrometer Test (CPT) cone measurements (pore pressure, tip and sleeve stress), which results in real-time, complementary data sets of soil type and hydrologic properties. The data system provides detailed analyses of pressure profiles and process histories for real-time display.

Expected Capabilities: The benefits of the Cone PermeameterTM method include: ? Cost for measurements are less than half of borehole measurements. ? Measurement is rapid and integrated with other geophysical measurements. ? Small volumes of injected fluid due to small region of influence. ? Rapid measurements (3-10 minutes per station). ? Minimizes impact of compacted soil due to penetrometer emplacement. ? Integrated with CPT geophysical measurements. ? Makes use of all the benefits of cone penetrometer emplacements: --Minimal secondary waste. --Rapid mobilization and setup. --Low unit measurement cost. --Mature technology. The initial field test of the Cone PermeameterTM system demonstrated its ability to conduct tests rapidly. In a period of 5 hours, 35 measurements were conducted in the saturated zone. These measurements were obtained concurrently with standard cone geophysical measurements, providing a highly integrated data set. Depending on the scenario, this approach will save at least 50 percent over conventional permeability measurement techniques, primarily because of the high cost of borehole formation with drilling techniques.

Sources: TMS
TSS [Title]: In-Situ Permeability Measurements with Direct Push Techniques

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents may have applicability.

Techn. Name: Multi-Analyte, Single-Fiber Optical Sensor

Tech #: 69

Ref ID: 383

Date Available: 12/31/1995

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

CMST

Description: Researchers at Tufts University have demonstrated and patented a unique technology that enables the placement of multiple sensors on a single optical fiber. Current estimates from Tufts researchers indicate the potential for up to 20 or more different sensors (for different target compounds) on a single 350 micrometer diameter optical fiber. This task describes a Lawrence Livermore National Laboratory/Tufts University collaboration for the development of such a technology for DOE site-specific requirements. The successful completion of this task will result in a single fiber sensor for the detection of four compounds, laboratory test results for same, and field prototype instrumentation for an FY95 demonstration at a DOE facility.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Commercially available. Development stopped awaiting deployment decision. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Zero Tension Lysimeters

Tech #: 80 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 715 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **CMST**

Description: A lysimeter is a device permanently installed in the soil to sample soil water, i.e., infiltration from snow-melt or rainfall. Zero-tension lysimeters (ZTLs) are especially appropriate for sampling particles (colloids) suspended in the water, in addition to the dissolved materials, because, in contrast to conventional lysimeters, ZTLs have no ceramic barrier or fiberglass wick to maintain tension on the water. The improved design ZTL consists of a polycarbonate or polytetrafluoroethylene (PTFE) cup that is placed below undisturbed soil material, and means for removing the sampled material. In cases where a hydraulically powered tube can be used to extract an undisturbed core of soil before placement of the lysimeter, the improved design has significant simplicity and speed of installation advantages over conventional designs.

Expected Capabilities: Many radioactive contaminants travel as colloids in groundwater and are not collected in standard lysimeters because the ceramic barrier or fiber- glass wick filter them out. Hence standard lysimeter sampling could miss detecting or monitoring radioactive contaminants in the sub- surface.

Sources: TMS

Notes/ Other Info: Transferred to user or industry to complete the development. No date given for completion. This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive constituents could have applicability.

Techn. Name: Ground Penetrating Radar

Tech #: 81 | **Date Available:** 12/31/1994 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1148 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **CMST**

Description: Ground Penetrating Radar

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor LTS burial areas could have applicability. Not much information available on this technology.

Techn. Name: Ground Based Laser Induced Fluorescence Imaging

Tech #: 84	**Date Available:**		Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 1999	**Past Investment($K):**	2510	**Future Investment($K):**	0	**CMST**

Description: This technology consists of a hand-held survey tool and an airborne system using laser-induced fluorescence techniques for the detection of uranium, heavy metals, organic compounds, and vegetation stress due to uptake of contaminants. Laser light is used to "excite" uranium oxide molecules that may be present as a surface contaminant. Energy is then released from the molecules in the form of fluorescence, which is then detected and displayed on a monitor attached to a laser. The laser can be operated in a panning motion to survey large areas quickly, or used to survey discreet two foot by two foot areas at a time. Unlike physical swipes, which must be collected from the actual surface being surveyed, the LIF instrument can be operated up to 10 meters away from the surface being studied. Detection of surface contamination occurs virtually instantaneously.
The LIFI was demonstrated at the Fernald Plant 1 in FY97. For more information see the Fernald LSDP homepage or the D&D Focus Area Homepage.

Expected Capabilities: Selectivity: Fluorescence techniques have the ability to detect and recognize spectral signatures that are not observable by conventional or baseline methods. As a screening tool, fluorescence allows for the determination of surface exposure, improving worker safety, and allowing a rapid assessment of hot spots. Screening Tool: The system can image at a distance, allowing access to out of reach areas. Spatial Resolution: The high spatial resolution of intensified charged coupled device (CCD) cameras and the time-resolved phosphorescence emission characteristic of the uranyl ion allow a picture to be created that shows the extent of surface uranium contamination. This visual image allows mitigation efforts to be focused on specific areas and that speeds the survey and lowers overall costs. At distances of 4 feet, the spatial resolution observed is better than 1 centimeter. Real Time: The real-time image processing of the data into a false color composite on a gray scale background allows the operator to quickly distinguish the uranium signature. Since the data are recorded as digital Tagged Image File Format (TIFF) files, it can be reviewed for planning and review of deactivation and decontamination activities. Portable: The present LIFI configuration is probably the only system that can record LIFI imagery from a single, portable system. No commercial equivalent to the LIFI technology exists. Cost-Effective: A cost-benefit analysis has shown that the system becomes a cheaper alternative to swipes and Geiger-Mueller Tube (GMT) meters at a relatively small area (Cost curves cross at 30,000 square feet). No Secondary Waste: As an optical technique, the LIFI system generates no waste. Operates in High Radiation Background: The system is not affected by underlying radiation sources such as pipes. This allows for the determination of surface contamination on a high radiation vessel.

Sources: TMS
TSS [Title]: Ground Based Laser Induced Fluorescence

Notes/ Other Info: No date for completion was given. This technology does not appear to be planned for LTS, but it's application to monitor movement of radionuclides and hazardous constituents could have applicability.

Techn. Name: **Monitor for Demonstrating the Effectiveness of Barrier Installation and Long-term Performance using Electrical Resistance Tomography**

Tech #: 86 | **Date Available:** 12/31/1996 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 2120 | **Past Investment($K):** 690 | **Future Investment($K):** 0 | **CMST**

Description: Electrical Impedance Tomagraphy (EIT) uses magnitude and phase information to allow entirely new imaging capability over electrical resistance tomography (magnitude only). EIT has been shown in the laboratory to directly image DNAPLs in the subsurface. The unique subsurface imaging capability of electrical resistance tomography allows real-time monitoring of the emplacement of a barrier, enabling holes to be filled as they are created. For barriers which allow liquid leak testing, ERT can detect minute leaks.

Expected Capabilities: Only technology capable of imaging the on-going emplacement allowing process control; By ensuring effective emplacement of a barrier, ERT saves the cost of second field mobilization to fix holes.

Sources: TMS
TSS [Title]: Electrical Resistance Tomography

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor LTS burial areas could have applicability.

Techn. Name: **Electrical Impedence Tomography (EIT) for DNAPL delineation in the Subsurface**

Tech #: 87 | **Date Available:** 12/31/1996 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 2121 | **Past Investment($K):** 200 | **Future Investment($K):** 0 | **CMST**

Description: Electrical Impedence Tomography (EIT) reconstructs the subsurface 3-D electrical impedence field tomographically from measurements of the impedence between pairs of points. The impedence is measured at several frequencies. DNAPL location can be inferred from the frequency dependence of the reconstructed impedence fields. This is an outgrowth of Electrical Resistance Tomography (TechID 17), used in monitoring environmental remediation operations such as soil heating and dynamic underground stripping as well as subsurface barrier integrity.

Expected Capabilities: A characterization system that can map DNAPLs in the subsurface is critical for assuring that site characterization does not miss them altogether greatly increasing public risk. This technology, combined with fiber optics has mapped out DNAPL plumes.

Sources: TMS
TSS [Title]: Electrical Impedance Tomography

Notes/ Other Info: Commercially available, but not implemented. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: **Induced Fluorescence Sensors for Direct Push Systems**

Tech #: 88	**Date Available:**	12/31/1999	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 2237	**Past Investment($K):**	50	**Future Investment($K):**	0	**CMST**

Description: The Laser Induced Fluorescence (LIF) Probe can be deployed by cone penetrometer for real-time, depth discrete delineation of contaminants that fluoresce under ultraviolet illumination, such as petroleum oils and libricants (POL) and co-contaminants in Dense Non-Aqueous Phase Liquids (DNAPLs). Several mature implementations of this technology exist, differing in illumination source and wavelengths and in the methods used to analyze the time and/or frequency spectra of the emitted fluorescence. This technology is one component of the DNAPL Toolbox (TechID 237).

Expected Capabilities: Induced fluorescence sensors for CPT are a cost-effective way to delineate subsurface contamination consisting of POL and used DNAPL. CPT methods in general are quick and generate minimal secondary waste.

Sources: TMS
TSS [Title]: Laser Induced Fluorescence Probe for Cone Penetrometer

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Sheen Ultrasonic Sensor

Tech #: 91	**Date Available:**	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 2301	**Past Investment($K):** 0	**Future Investment($K):** 0	**CMST**	

Description: The DoD and DOE are pursuing efforts to characterize and remediate thousands of contaminated sites in a cost-effective manner. These efforts are endeavoring to improve the quality of site characterization and remediation processes while minimizing the cost and increasing the efficiency of those processes. CPT technology offers numerous advantages because it is generally faster, less expensive, safer, and generates far less secondary waste than conventional drilling methods. As a result, DoD and DOE efforts have been focused on developing advanced sensors capable of being delivered into the subsurface environment by the cone penetrometer. As probe sizes have increased (from 1.44-inches to 1.75-inches and larger in outside diameter), the ability of the cone penetrometer to reach the desired depth for a given rig weight (reaction force) has been reduced accordingly. The integration of sonic drilling techniques with CPT will advance cone penetrometer sensor packages past the current depths of refusal in many soils and provide an efficient tool and technique for hazardous waste site characterization, remediation, and monitoring.
Applied Research Associates, Inc. (ARA) modified a standard Cone Penetrometer Test (CPT) system by mounting a vibratory mechanism above the push-frame allowing the option of vibrating the rod-string to enhance the effectiveness of advancing sensors into the ground. The drive head uses two counter-rotating eccentric weights to induce a sinusoidal driving force equivalent to the vertical acceleration of the eccentric weights times their mass. The vibratory head is mounted above the CPT clamp head by vibration isolators that limit the propagation of vibrations into the rest of the clamp system and truck. In this configuration, the vibratory head is clamped directly to the push rod, and the existing hydraulic push cylinders provide the bias load required for vibratory advancement of the CPT rods. The prototype drive-head has a vertical tube through its center to allow the passage of CPT rods without interfering with the normal clamp operation. The cone penetrometer with the sonic enhancement developed for the U. S. Department of Defense (DoD) and the U.S. Department of Energy (DOE) by ARA is referred to as the Sonic CPT.

Expected Capabilities: The ability to reach these depths at similar sites could significantly reduce characterization and monitoring costs for responsible parties. For example, during this testing and evaluation program, one of the Installation Restoration Program (IRP) managers at Camp Edwards expressed an interest in retrieving groundwater samples from approximately 100 feet bgs at one of their sites that is currently in the remediation phase. They were considering placing a recovery well at this particular location and wanted to be sure that it was within the plume. Using the Sonic CPT, several groundwater samples were retrieved for chemical analysis from the area of interest, allowing the IRP to make a more informed and cost-effective decision regarding the location of the recovery well. The other option for them was to bring in a conventional auger drill rig to conduct an exploratory boring at a cost of several thousand dollars.

Sources: TMS

Notes/ Other Info: No date for completion was given. This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive and hazardous constituents could have applicability.

Techn. Name: Spectral Gamma Probe

Tech #: 92

Ref ID: 2364

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

CMST

Description: An innovative Spectral Gamma Probe designed for in-situ detection of radionuclides has been developed by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) under the sponsorship of the U.S. Department of Energy (DOE). The enhanced Spectral Gamma Probe is intended for use as a site characterization tool at DOE waste sites containing radionuclides in the subsurface. The probe consists of a gamma radiation detection system that is driven into the subsurface using the Site Characterization and Analysis Penetrometer System (SCAPS) or other cone penetrometer truck. The sensor uses a NaI scintillation crystal to detect gamma radiation in the subsurface at the probe tip. The energy spectrum of the gamma rays emitted by the radioactive waste is analyzed to reveal the identity and relative concentration of the radioactive constituents.

Expected Capabilities: In situ measurements of specific radionuclide concentrations can provide significant reduction in cost and schedules for site characterization. Compared with the baseline technology of collecting soil samples and sending them offsite for laboratory analysis, the use of the spectral gamma probe deployed via cone penetrometer can provide significant cost savings, reduction or elimination of turn-around time for analyses, reduction of secondary waste generation, elimination of the need to transport potentially hazardous materials, and reduction in risk of human exposure during sampling and analysis.

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 2364
IPABS Response ID: 1147

Notes/ Other Info: Commercial development. No date for completion was given. This technology does not appear to be planned for LTS, but it's application to monitor movement of radioactive constituents could have applicability.

Techn. Name: Cone Penetrometer Testing Lysimeter

Tech #: 93

Ref ID: 2365

Date Available: 12/31/1997

Past Investment($K): 400

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

CMST

Description: Development of the Bladon lysimeter stemmed from the need for a technology capable of attaining timely soil water samples from the vadose zone using cone penetrometer push methods able to be used in characterization investigation efforts, not just long term monitoring. A standard lysimeter is a device that is installed in the subsurface to allow groundwater sampling of the vadose zone. The installation entails costly and time consuming drilling procedures. The lysimeter itself, usually a ceramic cup, collects water from the unsaturated sediments due to application of a suction. The Bladon lysimeter operates on this same standard idea but is modified for CPT installation and designed for rapid sample collection.
The Bladon Lysimeter is composed of a stainless steel body, a porous nickel sampling filter, and a stainless steel extraction tube. The stainless steel ram point was the same specifications as the standard cone penetrometer point. The nickel filter is highly hydrophilic, has 60% porosity with a narrow range of pore size, and is designed to withstand 15 tons of hydraulic driving force. A vacuum is applied to the filter to extract the soil water into a transfer vessel; that water is then transferred to the surface for volumetric and chemical analyses.

Expected Capabilities: Evaluation of the Bladon lysimeter proved it effective in several areas. Installation is quicker, easier, and more cost effective than baseline lysimeter installation, and generates little or no waste. Soil moisture samples of adequate volume for chemical analyses can be collected in a matter of hours in the vadose zone and an hour in the saturated zone. Soil moisture samples can be collected for a variety of soil types, up to 83 ft depth. Some soil moisture samples were collected within 48 hours from the vadose zone at each of the test sites, and most of these were of sufficient volume for chemical analysis. The chemical analyses were somewhat erratic, however, and the nickel filter was affected somewhat in acidic soils.

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 2365

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: GeoVis Video Camera System for CPT

Tech #: 94	**Date Available:**	12/31/1999	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 2399	**Past Investment($K):**	50	**Future Investment($K):**	0	**CMST**

Description: The GeoVIS Probe is an in-situ video imaging system developed by SPAWAR Systems Center, San Diego. GeoVIS is deployed with a cone penetrometer and used to acquire visual information about the subsurface. It consists of a CCD color camera, lens/focusing system, and white LED illumination system. The camera, mounted inside the probe, uses a sapphire window viewport. The GeoVIS Probe has been used successfully to delineate DNAPL and other colored compounds in the subsurface during several field applications. The GeoVIS can resolve features as small as 10 µm.

Expected Capabilities:

Sources: TMS
TSS [Title]: GeoVis Video Camera System for CPT Summary Sheet - Tech ID 2399

Notes/ Other Info: This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents may have applicability.

Techn. Name: Color Recognition Sensor for Direct Push Systems

Tech #: 96	**Date Available:**	9/30/1999	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 2949	**Past Investment($K):**	75	**Future Investment($K):**	0	**CMST**

Description: The Color Recognition Sensor is combined with a fluorescence sensor in Dakota Technology's Hyperlogger. This device makes optical measurements through a sapphire window in a cone penetrometer probe. These are converted to electrical signals and relayed to a lap-top computer on the surface. Measurements are made, stored, and analyzed in real time during a CP push. At the standard push rate of 2 cm/s, spatial resolution approaching 0.5 cm can be achieved, allowing detection and even rudimentary identification of thin layers, blobs, and ganglia of DNAPLs and other organic constituents in the subsurface. The fluorescence module measures emissions at three wavelengths, which are combined into a false color image: 350 nm is assigned to blue, 420 nm to green, and 480 nm to red. The resulting intensity/'spectral' log is superimposed on a background showing soil color; these are plotted as a function of depth. In the image shown in the Technology Summary Sheet, the 'blue' fluorescence peak at a depth of 63.3-64.3 ft corresponds to light colored soils. The 'blue' false-color could indicate a kerosene type product, although precise identification is not possible with only three emission channels. The Membrane Interface Probe (OST 2950) could be exchanged for the Hyperlogger to sample the contaminant and provide precise identification of the organic constituent(s) present at this depth.

Expected Capabilities: The Color Recognition Sensor, coupled with a fluorescence sensor in the Hyperlogger, provides continuous real-time indications of possible POL or DNAPL subsurface contamination during cone penetrometer pushes with spatial resolution approaching 0.5 cm.

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 2949

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: **Membrane Interface Probe System for Direct Push System**

Tech #: 97 | **Date Available:** 7/31/2001 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 2950 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **CMST**

Description: The Membrane Interface Probe System (MIPS) is a Cone Penetrometer- or Geoprobe-deployed probe for the field screening of high concentration dissolved Volatile Organic Compounds (VOCs). The MIPS incorporates a heated semi-permeable membrane into the cone penetrometer tip. VOCs diffuse through the membrane into a carrier gas, which circulates through tubing to analytical instruments at the surface. Once the MIPS probe is retracted, the hole can be grouted through the CP rod itself.

Expected Capabilities: The MIP allows for quick, depth-discrete detection and quantitation of dissolved phase organic constituents wherever the Cone Penetrometer can be deployed. Although the detection limit is not as low as with the baseline drilling, sampling and laboratory analysis technology, the time and cost savings available when the MIP can be used and meets DQOs can be substantial.

Sources: TMS
TSS [Title]: Summary Sheet #1 (01/13/00) for Tech ID 2950

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

Techn. Name: Subsurface Barrier Validation with the SEAtrace (TM) Monitoring System

Tech #: 67	**Date Available:**		Surveillance and Monitoring-Physical Barriers		
Ref ID: 308	**Past Investment($K):**	1661	**Future Investment($K):**	0	**CMST**

Description: The SEAtraceTM Monitoring System is a gaseous tracer-based subsurface barrier verification system developed for use on containment barrier structures located above the water table. Non-hazardous tracer gas is injected inside the barrier, and gas-sampling points are located outside of the barrier to detect the arrival of the tracer gas through breaches in the barrier structure. The SEAtraceTM Monitoring System integrates real-time soil-gas sample collection and analysis with a global optimization technique to locate and size flaws in barriers in real time. The system is self-powered (solar panels with battery backup), thermally controlled, remotely accessible through a cellular modem link, and meant to operate for months at a time without on-site user intervention.

Expected Capabilities: The SEAtraceTM barrier monitoring system is an enabling technology that provides quantitative barrier verification for installations above the water table where no capability currently exists: The approach is conservative in that it measures vapor leaks in a containment system where the greatest risks are posed by liquid leaks. SEAtraceTM provides a degree of resolution in both leak size and location that is unattainable with geophysical techniques. It is applicable to any impermeable barrier emplacement technology in the unsaturated zone. It uses readily available non-hazardous gaseous tracers. Tracer injection and vapor sampling ports are typically emplaced using direct push techniques, which avoid excessive drilling costs and secondary waste generation. The soil-gas monitoring system provides continuous and unattended contaminant plume measurements for remote site operation. In addition to assessing initial barrier integrity, the system can also provide long-term monitoring of contaminants in soil gases for surveillance of the containment system's performance over time.

Sources: TMS
TSS [Title]: Subsurface Barrier Validation With The SEAtrace (TM) Monitoring System

Notes/ Other Info: This technology appears to have direct applicability to LTS. No date was given for implementation. It does appear to be an on-going activity.

Techn. Name: Hydrogeologic Data Fusion

Tech #: 95	**Date Available:**		Surveillance and Monitoring-Subsurface Science	
Ref ID: 2944	**Past Investment($K):**	0	**Future Investment($K):** 0	**CMST**

Description: The fate and transport of contaminants in the subsurface requires knowledge of the hydrogeologic system. Site characterization typically involves the collection of various data sets needed to create a conceptual model that represents what´s known about contaminant migration in the subsurface at a particular site. Hydrogeologic Data Fusion is a mathematical tool that can be used to combine various types of geophysical, geologic, and hydrologic data from different types of sensors to estimate geologic and hydrogeologic properties. It can be especially useful at hazardous waste sites where the hydrology, geology, or contaminant distribution is significantly complex such that groundwater modeling is required to enable a reasonable and accurate prediction of subsurface conditions.

Expected Capabilities: The baseline technology for Hydrogeologic Data Fusion is manual trial and error model calibration of groundwater models. This calibration can be a very time-consuming process where the parameters are varied to produce the best fit to the actual measurements from the field. Relative to the baseline method, the advantages include: • Automatic estimation of the best fit to the measured parameters, • A significant reduction in the time to calibrate models, • A better match of estimated parameters to measured data and the conceptual model, • Quantification of parameter uncertainty, • Quantification of parameter correlation, • Quantification of uncertainty in contaminant transport. The use of Hydrogeologic Data Fusion results in a reduction in labor cost to calibrate complex groundwater models. • A LANL cost study estimates that if Hydrogeologic Data Fusion were applied at three hazardous waste sites at each of the fifteen major DOE facilities, a cost savings of approximately 3. 6 million dollars would result. • Use of Hydrogeologic Data Fusion to produce better quality groundwater modeling might ultimately result in: × A reduction in the number of monitoring wells, × A reduction in the number of treatment wells, × Better quality modeling leading to less conservative regulatory decision making (e. g. No Further Action decisions, × Better documentation of regulatory compliance.

Sources: TMS
TSS [Title]: Summary Sheet #1 for Tech ID 2944

Notes/ Other Info: Commercially available. This technology does not appear to be planned for LTS, but it's application to monitor movement of hazardous constituents could have applicability.

EM-50 Category: D&D

Techn. Name: Real Time Physiological Monitoring System

Tech #: 11 | **Date Available:** 3/7/2001 | Other-Other S&T

Ref ID: 2984 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **D&D**

Description: The Real-Time Physiological Monitoring System (RTPMS) is a commercially available system that provides real-time data on the immediate physiological conditions of workers as they carry out their job, typically wearing Personal Protective Equipment (PPE). The PPE required often includes multiple layers of semi-permeable/impermeable clothing and full-face respirators that can compromise the workers´ natural ability to cool him/herself, plus making visual observation of workers´ condition difficult for co-workers and supervisors.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Urethane Foam Void Filling

Tech #: 5	**Date Available:**	12/15/1998	Physical Barriers-Waste Forms		
Ref ID: 1816	**Past Investment($K):**	100	**Future Investment($K):**	0	**D&D**

Description: The concept behind this technology application was that vessel void spaces would be filled with a pumpable material that once solidified would be capable of withstanding the compressive load resulting from the overburden. Thus should the vessel's wall/shell degrade (i.e., rust) and fail over time, the solid void filling media would prevent subsidence of the OSDF cap. This particular demonstration used an expanded polyurethane foam as the void filling media. In the formation of a foam, two chemicals are mixed together. One of these chemicals is FE 800A; Polymeric diphenylmethane diisocyanate (MDI), which is the base ingredient for any polyurethane foam. The other ingredient is typically a proprietary mixture. The MDI presented a definite health hazard. However, once mixed with the second chemical component, the resulting polyurethane foam is safe for land disposal. The two chemicals are kept separate until they reach the mixing gun from which the mixture is immediately ejected. The two chemical ingredients leave the mixing gun as a liquid stream and shortly thereafter start to expand into a 'foam'. The speed at which the liquid expands to form the foam can be controlled through regulating both the temperature of the two chemical components and their ratio to one another. The foam in its liquid phase was allowed to expand to its maximum extent before the addition of more of the liquid mixture.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage - 7

Techn. Name: Low-Density Cellular Concrete Void Filling

Tech #: 7	**Date Available:**	8/15/1999	Physical Barriers-Waste Forms		
Ref ID: 1846	**Past Investment($K):**	105	**Future Investment($K):**	0	**D&D**

Description: The concept behind this technology application is that the vessel void spaces would be filled with a pumpable material that once solidified, would be capable of withstanding the compressive load resulting from the overburden. Thus, should the vessel's wall/shell degrade (i.e., rust) and fail over time, the solid void filling media would prevent subsidence of the OSDF's cap. This particular demonstration used a low-density cellular concrete (LDCC) as the void filling media. The LDCC is generated by producing into the cement-water mix (no aggregate), an aerated protein based surfactant (air bubbles), which greatly reduces the concrete density but still provides the necessary strength. The reason the LDCC was used, was to minimize the weight of the filled vessel so that it could be easily moved.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Portable X-Ray Fluorescence Spectrometer

Tech #: 1

Ref ID: 1790

Date Available:	12/15/1998	Surveillance and Monitoring-Data Collection/Samp/Anal	
Past Investment($K):	90	**Future Investment($K):** 0	**D&D**

Description: The portable Spectrace 9000 unit (TN Spectrace) provides for non-destructive, real-time elemental nalysis for solid, liquid, thin film, and powder samples. The system collects x-ray emission spectra from a sample after excitation with one or more radiation sources. The system analyzes elements of atomic number 11 and higher, at concentrations from a few parts per million to percent levels. This demonstration, performed in August 1996, involved the field use of the element detection capabilities of the Spectrace 9000 in the CP-5 Reactor Mezzanine Area. The detector was used in conjunction with a demonstration of the Accelerated Facility Characterization Process. The demonstration was conducted at the Argonne National Laboratory CP-5 Reactor D&D Project as part of the Large Scale Demonstration Program funded by DOE's Federal Energy Technology Center. The demonstration used a combination of X-ray fluorescence (XRF) equipment and traditional portable radiation detection equipment to test an improved characterization approach and to develop characterization data from three rooms in the CP-5 reactor. The XRF identified 25 elements quantitatively. Elevated levels of lead-based paint were found in portions of the demonstration area. These levels will require remediation action upon final site decommissioning. Concentrations of other elements were below levels of concern.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: **Wireless Remote Radiation Monitoring System (WRRMS)**

Tech #: 14

Ref ID: 2104

Date Available:	5/15/1997	Surveillance and Monitoring-Data Collection/Samp/Anal	
Past Investment($K):	61	**Future Investment($K):**	0

D&D

Description: The RadStar Wireless Remote Monitoring System, developed by SAIC, monitors personnel dose and area exposure rate remotely from a predetermined command center located outside radioactively contaminated areas. A host personal computer monitors and records information transmitted from electronic dosimeters and collected by a transceiver base station using RadStar software. A radio transceiving alarming electronic dosimeter, wireless radio components, radiation detector, and a 9-V alkaline battery are contained in a small case worn by personnel. A dosimeter reader reads the dosimeters and resets them after use. The monitor weighs less than 400 g and is designed for gamma detection. Each dosimeter can be preset to alarm at a set point with either an audible alarm or light-emitting diode and will warn both the worker and the base station. Straight line signals can be transmitted over 10,000 ft. The system was demonstrated at Hanford´s C Reactor at various locations while personnel performed daily routine D&D activities.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Remote Surveillance of Facilities Awaiting D&D

Tech #: 16

Ref ID: 2377

Date Available:	9/6/2000
Past Investment($K):	0
Future Investment($K):	0

Surveillance and Monitoring-Data Collection/Samp/Anal

D&D

Description: The purpose of this three-year Florida International University Hemispheric Center for Environmental Technology (FIU-HCET) investigation (initiated in FY98) is to develop a remote surveillance system to monitor the facilities, which are closed and are awaiting decontamination and decommissioning. Such a system should provide continuous and inexpensive monitoring of the facility and reduce the need for labor-intensive and hazardous surveys. The system will be capable of collecting data from a DOE site (remote station) and transmitting the data to a central location (base station). The type of data collected will depend on the site-specific needs. From discussions held with DOE management and operations contractor personnel from Hanford, the SRS, and Lockheed Martin Idaho Technology Company (LMITCO), it was learned that most of the sites are in need of monitors for water level, water from leaky roofs, temperature, humidity, air activity, and gamma radiation. An outline of the remote surveillance system was made. The system consists of sensors of various parameters to be monitored, data collection and transmission modules (data-logger, RF module, and RF transmitter or a telemetry system and a transceiver at the base station with computer for display, storage, and retrieval of data). Since the closed sites may not have main power supplies, an alternative method of solar-powering the system was considered.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -5

Techn. Name: Gamma Ray Imaging System

Tech #: 3

Ref ID: 1793

Date Available:	11/15/1998
Past Investment($K):	57

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	0

D&D

Description: The technology is owned by BNFL/Pajarito Scientific Co. (PSC), Los Alamos, NM. The system consists of a 20 mm (dia) x 22 mm (long) CsI(Tl) detector, surrounded by truncated cone tungsten collimator with variable view angle (2, 4, and 9 degrees). This system is also equipped with a LASER range finder that determines the location of contamination (radiation) within 2 cm at a distance of approximately 270 cm from surfaces. In addition the system employs a high-resolution video camera to provide pictures of measurement locations within its view angle. Reports generated by the BNFL RadScan 600 are two-dimensional angular plots of Cs-137 and Co-60 contamination level in units of counts per second (cps). These plots can be in the form of color-coded surface plots, contour plots, or log plots. All radiological readings are stored within a database in the form of a gamma spectrum for each horizontal and vertical angle position. The cps readings can be translated to mR/h simply by multiplying the cps by a predetermined conversion factor. Similarly, the angle coordinates can easily be transformed into x-y coordinates.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Mobile Automated Characterization System

Tech #: 4 | **Date Available:** 4/15/1999 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1798 | **Past Investment($K):** 566 | **Future Investment($K):** 0 | **D&D**

Description: The Mobile Automated Characterization System (MACS) has been developed by Oak Ridge National Laboratory and the Savannah River Technology Center for the U.S. Department of Energy's Robotics Technology Development Program to address this need. MACS is a commercially-available, battery-powered, autonomous robot base supplemented by a laser positioning system and a scintillation detector array. MACS can detect alpha and beta contamination, and moves over floors at a speed of one inch per second. MACS was demonstrated in July 1996 for the first time in a nuclear facility at Argonne National Laboratory's CP-5 reactor as part of the CP-5 Large Scale Demonstration Program funded by DOE's Federal Energy Technology Center. The test area for the demonstration was a concrete area on the service floor of CP-5, where portions of the floor contained fixed contamination. Contamination levels measured by baseline manual surveys ranged from less than free release for beta to greater than 500,000 dpm beta per 100 cm2.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage-7

Techn. Name: Field Transportable Beta Spectrometer

Tech #: 8 | **Date Available:** 12/15/1998 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1853 | **Past Investment($K):** 75 | **Future Investment($K):** 0 | **D&D**

Description: This transportable instrument uses solid scintillation, coincident counting, and low background photomultiplier tubes to count filters and other solid media. Instrument software provides for real-time spectral analysis. Detection of Sr-90, Ce-137, Tc-99 and other beta emitters can be achieved in the 40 pCi range. A field demonstration at CP-5 allows for evaluation of potential cost and performance efficiencies.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: FRHAM-TEX Anti Contamination Suit

Tech #: 9 | **Date Available:** 2/10/1998 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1854 | **Past Investment($K):** 50 | **Future Investment($K):** 0 | **D&D**

Description: The Frham-Tex Anti Contamination Suit utilizes a one-piece disposable, breathable, waterproof coverall for hot/wet atmospheres. Coverall construction consists of multiple layers of hydrophilic film and polyester sontara. Cost and schedule efficiencies may be realized through appropriate application of this worker health and safety technology.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: NuFab Anti Contamination Suit

Tech #: 10 | **Date Available:** 2/15/1998 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1855 | **Past Investment($K):** 50 | **Future Investment($K):** 0 | **D&D**

Description: This technology will demonstrate worker health and safety advances with the use of the one-piece, disposable waterproof coverall in hot/wet atmospheres. The coveralls are constructed of a tri-laminated composite material using spun bonded non-woven polypropylene and microporous layers. Cost and schedule efficiencies may be realized through utilization of this technology.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Personal Ice Cooling System (PICS)

Tech #: 12

Ref ID: 1898

Date Available:	7/15/1998
Past Investment($K):	325

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	0

D&D

Description: The Personal Ice Cooling System (PICS) is a self-contained core body temperature control system that uses tap water ice as a coolant. The coolant is circulated through the suit by a rate adjustable, battery-powered pump. The suits are available as shirts or vests, in a variety of sizes. Water is frozen in bottles that are worn outside of Anti-Cs in a sealed, insulated bag. These frozen coolant bottles and the circulating pump are incorporated into the suits with a comfortable support harness system. The coolant is circulated through the suit via an umbilical cord with an Anti-Cs pass through connector that is connected to the tubing in the garmet. This design allows for ease of changing the coolant when it has expired as well as allowing for the adjustment of cooling, while providing a barrier to the passing of contaminants to the worker. The rate adjustment, ´OFF-LO-HI,´ allows the worker to adjust cooling based on work load or personal preference.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Sealed-Seam Sack Suit

Tech #: 13 | **Date Available:** 9/15/1997 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1954 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **D&D**

Description: From October 1996 through August 1997, a total of six different innovative personal protective clothing were demonstrated for contamination protection, safety, and comfort under the 105-C Reactor LSDDP. LANL and Hanford Industrial Safety & Hygiene Departments performed heat stress and temperature measurements in an environmental chamber, and fabric penetration tests (one test on the fabric and the other while the fabric was worn). The suits tested included: Comfort Guard 150 FRHAM KoolSuit Kappler ProShield I and ProShield II Kappler NuFab Kappler Tyvek Copiah Creek (cotton baseline) All six suits were tested against baseline using three different sizes of personnel in two environmental conditions. The tests were conducted at 35 degree C with a relative humidity of 70%, and at 0 degree C with a relative humidity of 50%. Following demonstration (FY1997) of six innovative and disposable personal protective garments, the Kappler Pro/Shield Suit and Comfort Guard 150 Suits were selected for subsequent use at Hanford´s reactor interim safe storage projects. The Kappler Pro/Shield Suit is constructed of white, nonwoven laminated point-bonded material, and the Comfort Guard 150 Suit is constructed of a yellow, nonwoven material. Each suit provides improved durability for physical and temperature effects, flexibility, and compatibility with other equipment.

Expected Capabilities:

Sources:

Notes/ Other Info: Current Gate stage -7

Techn. Name: Electromagnetic Radiography

Tech #: 17

Ref ID: 2390

Date Available: 8/15/1999

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

D&D

Description: Electromagnetic Radiography (EMR) is a non-destructive characterization technology that uses ultra-high impulses operating in the radio-frequency spectrum to provide subsurface characterization. EMR quantifies underground solids, liquids, chemicals, DNAPLs, heavy metals, etc., and provides a three-dimensional map of their geometry and location.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -6

Techn. Name: Passive Tritium Air and Surface Monitor

Tech #: 18

Ref ID: 2957

Date Available: 9/15/2000

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

D&D

Description: he E-PERM® (Electret-Passive Environmental Radiation Monitor) system for tritium monitoring consists essentially of three components: (1) a passive integrating ionization chamber made of electrically conducting thin wafers of plastic (polypropylene) with volumes ranging from 1 cubic centimeter to approximately 1000 cubic centimeters, (2) a very stable electrically charged Teflon disk known as the electret which serves as both a source of an electrostatic field and a sensor inside the ionization chamber, and (3) a portable, battery powered, microprocessor-operated electret voltage reader and data logger. The chamber is made of carbon filled polypropylene and the window is made of thick carbon coated (7 mg per sq. cm) Tyvek*) material which is highly transparent to water vapor. The Teflon electret, mounted in carbon filled polypropylene, is operated by a spring loaded shutter. When the charged electret, or sensor, is loaded into the chamber, the electret establishes an electrostatic field within the chamber, thus forming a passive ionization chamber. The radiation source is then introduced into this chamber, or conversely, the chamber is deployed directly into an area or over a solid surface where the average tritium concentration in air or on the solid surface is to be measured. The tritium gas or tritiated water vapor or beta particles in the case of solid surfaces diffuse through the Tyvek filter and ionize the air molecules. These negatively ionized air molecules are attracted to the positively charged electret, thereby reducing the original electret charge and consequently, voltage. The Voltage Reader measures the electret voltage and records the current time. By measuring the initial and final voltages and the elapsed time, the voltage discharge rate of the electret is determined and the average tritium concentration calculated.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -6

Techn. Name: Radon Monitoring System

Tech #: 19

Ref ID: 2985

Date Available: 4/15/2001

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

D&D

Description: Continuous Radon Monitoring at the FEMP is performed for the following reasons: a) To ensure compliance with radon concentration limits established in DOE Order 5400.5, Radiation Protection of the Public and Environment; b) To satisfy mandated monitoring requirements under the Federal Facilities Agreement with regard to National Emission Standards for Hazardous Air Pollutants Subpart Q; c) To quickly trend radon emissions from radon-generating materials contained in on-site waste storage areas in order to gauge potential impacts to the public. The present monitoring program utilizes a network of continuous radon monitors to measure ambient radon concentrations. The monitoring program is mostly concentrated near the K65 Silos, the waste pit areas of the FEMP, and at the facility perimeter.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Russian 3-D Gamma Camera

Tech #: 20

Ref ID: 2991

Date Available: 10/1/2000

Past Investment($K): 0

Future Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

D&D

Description: The technology is a 3D-Gamma Locator Device (GLD) to provide three-dimensional characterization of radioactivity in areas of extremely high activity. It is a robotic unit that provides feedback to a computer based control system. The sensor is mounted on a tracked vehicle and operated remotely using a vehicle mounted camera. This technology stands out among its competitors because, first, it operates on radio frequencies completely non-tethered and it can maneuver around corners and transmit through walls. Second, it has a broader range of sensitivity (i.e., 60KeV to 6MeV compared to 100KeV to 2MeV). And third, it has a broader scanning angle (i.e., 330?horizontal and 125? vertical compared to 73? horizontal and 55? vertical). This technology is scheduled for demonstration at the Test Area North (TAN) 616 facility in July 2001

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -6

Techn. Name: Compact Subsurface Investigation System

Tech #: 15

Ref ID: 2153

Date Available:	4/15/1998
Past Investment($K):	135

Surveillance and Monitoring-Subsurface Science

Future Investment($K):	0

D&D

Description: The Geoprobe Model 540, is a compact subsurface soil investigation system capable of retrieving soil samples. The Geoprobe Model 540 is a 31-in. wide unit, capable of sampling in congested areas that standard soil sampling equipment would not be able to fit into to conduct sample retrieval. The unit hydraulically hammers and/or pushes a metal sampling tube into soil and hydraulically withdraws the sample to the surface. The diameters of the typical sampling tubes are such that inner plastic sample holders are used that are 1.25-in. or 2-in. inside diameter. The length of sample that can be taken with each sample withdrawal is up to two ft. The Geoprobe Model 540 is equipped with two wheels and can be moved around similar to a cart. The unit is also connected with flexible hydraulic hoses to a remote hydraulic power unit.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

EM-50 Category: EMSP

Techn. Name: Radiation Effects on Materials in the Near-Field of Nuclear Waste Repository

Tech #: 221 | **Date Available:** 3/14/2003 | Ecosystem Monitoring-Field Data

Ref ID: 54691 | **Past Investment($K):** 408 | **Future Investment($K):** 0 | **EMSP**

Description: The principal sources of radiation in high-level nuclear waste are decay of the fission products (e.g., 137Cs and 90Sr) and decay of the actinide elements (e.g., U, Np, Pu, Am and Cm). Both types of radiation can cause important chemical and physical changes in materials (e.g., increase in leach rates, volume expansion, solid state radiolysis and bubble formation, and reduced cation exchange capacity). The radiation-solid interactions are complex because they involve a combination of ionization effects due to electronic excitations and ballistic effects due to elastic collisions. The strength of the radiation field decreases dramatically with time, and the type of radiation damage varies over time (?-decay damage due to actinides dominates over ?-decay effects due to fission products with increasing time due to the long half-lives of the actinides). Further, the radiation effects vary as a function of the type of solid (ionic vs. covalent), the type of damage (inelastic vs. elastic interactions), the temperature of the irradiation, and the kinetics of the annealing mechanisms.

We propose a systematic study of elastic and inelastic damage effects in materials in the near-field. These include: 1.) waste forms (glass and crystalline ceramics); 2.) alteration products of waste forms (clays and zeolites); 3.) back-fill materials (clays and zeolites). We have selected materials whose durability or chemical behavior can potentially have a major effect on the retention of radionuclides (e.g., monazite as a waste form; smectite clays in back-fill), but for which there is very little previous systematic study. We have not included canister materials in this research, as there is already a substantial body of previous work on radiation effects in metals.

Expected Capabilities: Successful, demonstrated containment of radionuclides in the near-field can greatly reduce the complexity of the performance assessment analysis of a geologic repository. The chemical durability of the waste form, the corrosion rate of the canister, and the physical and chemical integrity of the back-fill provide important barriers to the release of radionuclides. However, near-field containment of radionuclides depends critically on the behavior of these materials in a radiation field.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Permanganate Treatment of DNAPLs in Reactive Barriers and Source Zone Flooding Schemes**

Tech #: 216 | **Date Available:** 9/14/2000 | Physical Barriers-Physical Barriers

Ref ID: 54585 | **Past Investment($K):** 351 | **Future Investment($K):** 0 | **EMSP**

Description: The specific objectives of this study are (1) to describe through batch experiments the kinetics and mechanisms by which potassium permanganate oxidizes dissolved tetrachloroethene (PCE), trichloroethene (TCE), and dichloroethene (DCE), (2) to examine using column studies the nature and kinetics of reactions between potassium permanganate, residual DNAPLs (PCE, TCE, and DCE) and porous medium solids, (3) to represent the process understanding in flow and transport models that demonstrate the potential applicability of the approach, and (4) to apply the resulting computer code in the development of appropriate field tests for assessing the approach.

Expected Capabilities: The goals of this study are (1) to elucidate the basic mechanisms by which potassium permanganate oxidizes common chlorinated solvents, various constituents in aqueous solution, and porous-medium solids, and (2) to assess the potential for chemical oxidation by potassium permanganate to serve as a remedial scheme involving either source zone flooding or reactive barriers. The research is a combined experimental/modeling study that builds on our extensive previous work in the area of reactive barrier systems, and modeling of reactive contaminant transport.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **On the Inclusion of the Interfacial Area Between Phases in the Physical and Mathematical Description of Subsurface Multiphase Flow**

Tech #: 214	**Date Available:**	9/14/2000	Subsurface Science-Basic Understanding		
Ref ID: 54576	**Past Investment($K):**	845	**Future Investment($K):**	0	**EMSP**

Description: A distinguishing feature of multi-phase subsurface flow in comparison to single phase flow is the existence of fluid-fluid interfaces. These interfaces define phase boundaries at the pore scale and influence overall system behavior in many important ways. For example, fluid-fluid interfaces support non-zero stresses, allowing for different phase pressures across each interface. In problems of inter-phase mass transfer, such as evaporation in air-water systems or dissolution in hydrocarbon-water systems, all mass is exchanged via the interfaces. While interfaces are central to multi-phase flow physics and associated contaminant transport, their treatment in traditional porous-media theories has been given little attention. Recent theoretical work provides a general framework within which interfacial area is incorporated explicitly into volume-averaged equations for conservation of mass, momentum, and energy. This leads to an expanded set of continuum-scale equations that carry the overhead burden of the associated set of expanded constitutive relationships. To make these equations a scientifically useful tool for the study of the soil environment, parameterization of the constitutive forms must occur. This parameterization requires that the equations be studied in light of the actual behavior of porous media systems. To perform the early stages of this work effectively, the porous media must be controlled, well-understood systems that lend themselves to careful scientific analysis.

Expected Capabilities: The present research will contribute to the improved understanding and precise physical description of multiphase subsurface flow by combining theoretical derivation of equations, lattice Boltzmann modeling of hydrodynamics to identify characteristics and parameters (see also research by ref="http://www.lanl.gov/cgi-bin/fonelink.pl/111177" Dr. Wendy E. Soll at LANL), and solution of the field-scale equations using a discrete numerical method to assess the advantages and disadvantages of the complete theory (see also research by href="mailto:afbt@llnl.gov">Dr. Andrew Tompson at LLNL). This approach includes both fundamental scientific inquiry and a path for inclusion of the scientific results obtained in a technical tool that will improve assessment capabilities for multiphase flow situations that have arisen due to spills of organic materials in the natural environment.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Comparison of the Bioavailability of Elemental Waste Laden Soils Using in vivo and in vitro Analytical Methodology, and Refinement of Exposure/Dose Models**

Tech #: 215	**Date Available:**	6/30/1999	Subsurface Science-Basic Understanding		
Ref ID: 54584	**Past Investment($K):**	506	**Future Investment($K):**	0	**EMSP**

Description: Hazardous waste contamination problems are prevalent in soils at DOE sites. Currently, they can be prioritized by estimating the human exposure and health risks from potential human contact with contaminants based upon the total extractable levels of contaminants of concern present in the soil or soil/waste matrix. This is done for single and multi-route exposure conditions with exposure via ingestion of contaminants in the soil being a major concern. Since it is anticipated that portions of some DOE sites will have parkland, commercial or residential restorations, a major concern is exposure of children to wastes. Studies have shown that children ingest between 40-200 mg of soil/day, and that children who suffer from PICA will ingest even larger quantities. These data have been tabulated by the American Industrial Research Council. The total extractable concentration of a contaminant present in the soil is not the best estimator of exposure since the human digestive system does not have the capacity to extract all of the contaminant from a soil matrix. Conversely, a determination of the bioavailable portion of the contaminants in the soil/waste can be used by risk analysts and assessors to more accurately estimate the risk via ingestion for individual waste sites. Use of the concentration present in a simulated bioavailable fraction is a better indicator of ingestion risk from a waste contaminated soil because it represents the portion of the contaminant mass which will yield exposure, uptake and then the internal dose to an individual or a sub-group of a population. To date the difficulty in obtaining an accurate assessment of the internal dose is caused by the lack of scientific information on the degree to which a contaminant will accumulate in bodily fluids and will be made available for migration across the membranes within the digestive system. The uncertainties associated with exposure/dose calculations derived from total elemental concentrations can be overcome by developing a procedure that accurately estimates the bioavailable fraction of the contaminant found in a particular soil or soil/waste mixture. Some previous research has been conducted which examined the possibility of developing a synthetic extraction fluid system. A physiologically based bioaccessibility test for lead and arsenic has been published by Ruby et al. for mining crustal material. They have also evaluated geochemical and physiological variables, and made comparisons with in vivo rabbit data and dissolution kinetics of the crustal material under simulated gastric conditions. The TNO Nutrition and Food Research Institute of the Netherlands focuses on the bioavailability of inorganic arsenic from Bog-ore. They use a system to mimic the stomach and intestine. Our system is the only one to use all digestive juices, and attempts to look at a variety of different types of waste-soil situations. It will be used as the basis for the experiments.

Previous research conducted by our laboratory on waste-laden soils in New Jersey, has shown that in specific situations, e.g. sites contaminated with dioxin and chromium, the matrix that binds a toxicant to the soil or components within the soil will alter the availability of the contaminants to be solvated by different extractants. If it is difficult to liberate the total concentration of the elements from a soil, even with concentrated acids and high temperatures and pressures, then the bioavailability of the elements would be uncertain. The bioavailability of elemental contaminants should be estimated by extracting with biological fluids (e.g. intestinal fluids). Analysts have routinely relied on a conventional definition of total extractable elements obtained by using EPA method 3015, 3050, or 3051 when reporting a soil concentration used in an exposure assessment. In reality, bio-fluids may only solubilize a small percentage of the totalelements present in the soil, and traditional extraction techniques can lead to artificially high estimates of internal dose, and uncertain/unrealistic estimates of the risk to a population.

The extractability of contaminants affects its transport into various organ systems within the body. Assuming the contaminants will undergo dissolution and absorption by specific target tissues and organs, artificially high estimations of the bioavailable fraction or 100% bioavailability will alter internal dose estimates. The ratio of the total amount of material present in the soil/waste matrix to that which is available for dissolution in a bio-fluid extractant gives an indication of the bioavailability of the contaminant.

Our hypotheses are: 1) the more closely the synthetic, in vitro, extractant mimics the extraction properties of the human digestive bio-fluids, the more accurate will be the estimate of an internal dose; 2) performance can be evaluated by in vivo studies with a rat model and quantitative examination of a mass balance calculation, and dose estimates from model simulations for the in vitro and in vivo system; and 3) the concentration of the elements Pv, U, Cd, Cr and Cs present in the bioavailable fraction obtained with a synthetic extraction system will be a better indicator of contaminant ingestion from a

contaminated soil because it represents the portion of the mass which can yield exposure, uptake and then the internal dose to an individual.

Rationale

Our concern about bioavailability is derived from the fact that a major route of exposure to elements present in soils and hazardous wastes is through ingestion, especially among young children. For example, soil accumulates on the hand, or in food, and it is then transferred to the mouth by normal activities: consuming food, wiping oneÆs mouth, or teething, etc. Once inside the mouth the soil will encounter the same biological processes that are encountered by edible material. It will interact in succession with saliva, gastric juice and the intestinal fluids under physiological conditions of temperature and pH. It is under this sequence of conditions that the data derived from a synthetic bio-fluid extraction system can provide a more accurate assessment of the potential or internal doses for elements.

Previous research with synthetic bio-fluids has been directed toward different aspects of physiological modeling. Synthetic analogs have been used to predict uptake of drugs, or nutritional compounds from food supplements. They have been used to model wear characteristics of watches or tooth fillings. They have also been employed at EOHSI and in other laboratories to begin to define the bio-available fraction of a contaminated matrix. Although each study has had different goals and the synthetic bio-fluids were prepared with different degrees of thoroughness, they all showed that the bio-fluids could not extract the target compound from a matrix with 100% efficiency. Recently Ruby et al. looked at the bioavailability of arsenic in a specific matrix, mining crustal material, and showed significant amounts as being unavailable for extraction. The developmental studies currently underway in the EOHSI laboratories are performed in a sequential synthetic digestive extraction system which was reacted with NIST Montana soil. The extraction efficiency was found to be 50% or less for the metals: Cd, As, and Pb and roughly 5% for Cr. The synthetic system was then applied to an actual soil/waste site mixture from Jersey City, NJ. The results found that only 4% of the chromium, and 3% of the lead extracted by concentrated acid digesting at a high temperature could be extracted by the EOHSI synthetic bio-fluids system. This system most closely follows the physiological digestion process, and will be used as the basic extraction system for the experiments.

Elemental solubility in a bio-fluid is expected to be dependent on both the soil matrix and the form of the metal within the soil. The variety of soil and crustal material present in urban locations throughout the United States complicates the situation since a potential exposure should be characterized using the site specific analyses. Unfortunately, this is not currently the case. The degree to which elements bind to a matrix may be also governed by some of the same thermodynamic properties that govern its transport properties through the soil.

With the number of DOE hazardous waste sites in the United States that require risk assessment, use of animal models as the main vehicle for determining the bioavailable fraction is neither practical nor cost effective. A general technique to extract soils or wastes that employs synthetic bio-fluids that approach physiological conditions can be a practical cost effective alternative to animal studies and it can be done routinely on a wide variety of soil and soil/waste mixtures. It can also be tailored to more closely match the concentrations of physiological constituents found in a human. The research will be able to evaluate the performance of a synthetic bio-fluid extraction system using an in vivo animal model as the reference for bioavailability of each element.

Expected Capabilities:

1.Use the synthetic analogs in a model system to extract elements from actual waste laden soils before and after application of remediation strategies and determine the bioavailable fraction of those elements under typical physiological conditions.

2.Conduct a performance experiment for selected known wastes using an in vivo animal (rat) feeding model and the synthetic analog digestive system model to compare the percentage of each element that is bioavailable in each model.

3.Conduct exposure analyses and dose analyses using the elements extracted by each ôingestionö experiment conducted in #3 and for the total elemental concentrations extracted from the soil/waste matrix and compare the results.

4.Improve our current exposure/pharmacokinetic components of the Exposure and Dose Modeling and Analysis System (EDMAS) for better estimations of the internal and delivered dose.

5.Optimize the synthetic extraction methodology employed for use as a routine assay of contaminated soils.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **The Migration and Entrapment of DNAPLs in Physically and Chemically Heterogeneous Porous Media**

Tech #: 218	**Date Available:**	9/14/2003	Subsurface Science-Basic Understanding		
Ref ID: 54680	**Past Investment($K):**	582	**Future Investment($K):**	0	**EMSP**

Description: The migration and entrapment of DNAPLs in the subsurface environment is typically believed to be controlled by physical heterogeneities; i.e, layers and lenses of contrasting soil texture. The rationale for this assumption is that capillarity, as determined by the soil texture, is the dominant transport mechanism. Capillarity also depends on interfacial tension and medium wettability. Interfacial tension and medium wettability may be spatially and temporally dependent due to variations in aqueous phase chemistry, contaminant aging, and/or variations in mineralogy and organic matter distributions. Such chemical heterogeneities have largely been ignored to date, even though they are known to have dramatic effects on the hydraulic property relations. Numerical multiphase flow and transport models typically assume that solids are water-wet and that interfacial tension is constant. The primary objective of this research is to investigate the influence of coupled physical and chemical heterogeneities on the migration and entrapment of DNAPLs. This objective will be accomplished through a combination of laboratory and numerical experiments. Laboratory experiments will be conducted to examine: (i) aqueous phase chemistry effects on medium wettability and interfacial tension; and (ii) relative permeability-saturation-capillary pressure relations for chemically heterogeneous systems.

Expected Capabilities: An important objective of this research is to modify a two-dimensional multiphase flow and transport model to account for chemically and physically heterogeneous systems. This numerical simulator will be used in conjunction with independently measured parameters to simulate two-dimensional DNAPL infiltration experiments. Comparisons of simulated and laboratory data will provide a means to experimentally validate this model. The validated numerical simulator will subsequently be employed to investigate various innovative remediation schemes such as the use of surfactants and in situ wettability alteration. The accomplishment of the research herein will: (i) lead to a better understanding of the way aqueous phase chemistry changes medium wettability; (ii) validate and/or lead to the development of methods to predict and model wettability effects on hydraulic property relations; (iii) lead to the development of a multiphase flow simulator that accounts for fractional wettability and concentration dependent interfacial properties; (iv) lead to an improved knowledge of the effects of pore-scale variability on scale-up issues in multiphase systems; (v) provide an understanding of the interaction of chemical and physical heterogeneity on DNAPL flow and entrapment; (vi) provide two-dimensional laboratory data sets to validate multiphase flow models for physically and chemically heterogeneous systems; and (vii) facilitate the development and implementation of innovative remediation strategies.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Dynamics of Coupled Contaminant and Microbial Transport in Heterogeneous Porous Media**

Tech #: 219	**Date Available:**	12/31/1999	Subsurface Science-Basic Understanding		
Ref ID: 54681	**Past Investment($K):**	2036	**Future Investment($K):**	0	**EMSP**

Description: This interdisciplinary research project will provide fundamental information on the attachment/detachment dynamics of anaerobic bacteria in heterogeneous porous media under growth and growth-limiting conditions. Experiments will provide information on passive and active attachment/detachment mechanisms used by growing anaerobes capable of reductive dechlorination. Theoretical representations of these attachment/detachment mechanisms will be incorporated into existing flow and transport models that incorporate heterogeneity effects and can be used to predict behavior at field scales. These mechanistic-based models will be tested against experimental data provided through controlled laboratory experiments in heterogeneous porous media in large (meter) 2-D flow cells.

The multidisciplinary team contributing to this project has evolved from previous collaborations under DOE's Subsurface Science Program and provides strong expertise in bacterial adhesion mechanisms and transport, physiology and phylogeny of methanogenic bacteria, bioreactive transport theory in heterogeneous porous media, and process scaling.

Expected Capabilities: Dynamic microbial attachment/detachment occurs in subsurface systems in response to changing environmental conditions caused by contaminant movement and degradation. Understanding the environmental conditions and mechanisms by which anaerobic bacteria partition between aqueous and solid phases is a critical requirement for designing and evaluating in situ bioremediation efforts.

In addition to a mechanistic-based predictive model, this research will lead to new theories for the transient spatial distribution of microbial populations and contaminant plumes in heterogeneous porous media, improving our capability for designing staged remediation strategies for dealing with mixed contaminants.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Characterization of Contaminant Transport Using Naturally-Occurring U-Series Disequilibria**

Tech #: 222

Ref ID: 54741

Date Available:	4/30/2001	Subsurface Science-Basic Understanding		
Past Investment($K):	900	**Future Investment($K):**	0	**EMSP**

Description: We propose such a study using the naturally-occurring U and Th decay-series disequilibria. The work of ours and other researchers have shown that the parent/daughter disequilibrium patterns existing in groundwater systems can be modeled in terms of local nuclide mass balance to arrive at such information as the rock-water contact time (fluid flow) and rates of contaminant transport (taking into account the retardation effect due to nuclide/rock interaction contaminants at INEL by grouping them into three categories, represented by isotopes of (1) Th and Pa, (2) U and (3) Ra. Mass spectrometric measurements of these elements will be emphasized in order to minimize sample size requirements and to maximize precision.

Expected Capabilities: The interactions of mixed wastes containing radionuclides with solid rock surface and the mobility of the radionuclides in aquifer systems depend not only on the chemistry of the nuclides and the physico-chemical effects of radioactive decay, but also on the site-specific hydrogeology. Thus, to characterize contaminant transport, it is best to cross-check figures derived from any small-scale laboratory experiments over limited times with that obtained from field-oriented, natural analog studies.

Results will form the data base for a model code for computing : (1) Fluid residence time (transport rates) in the basalt aquifers at various locations, (2) The in-situ adsorption and desorption rate constants, as well as the retardation factors, of various radionuclide wastes, and (3) Rock dissolution rate and its relation to preferential flow and contaminant transport in the fractured rocks.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Establishing a Quantitative Functional Relationship Between Capillary Pressure, Saturation and Interfacial Area**

Tech #: 223

Ref ID: 54793

Date Available:	9/14/2000	Subsurface Science-Basic Understanding		
Past Investment($K):	962	**Future Investment($K):**	0	**EMSP**

Description: Through an integrated and focused research program that is comprised of theoretical, computational and experimental efforts this research effort is directed at: (1) improving on newly developed laboratory techniques to quantify and directly measure the functional relationship between phase interfacial area (a), saturation (S) and capillary pressure (Pc); (2) developing new computational algorithms in conjunction with laboratory measurements to predict Pc, S, and a; (3) testing exciting theory and developing new theory to describe the relationship between P{sub c}, S and a at the large scale; and (4) synthesizing the results of the experimental, computational and theoretical investigative efforts to develop a genetic model based upon an intrinsic soil metric to describe the functional dependence of Pc, S, and a.

Expected Capabilities: The results of this research could be used to generate a site specific soil moisture characteristic surface. Ultimately the results of this research could served as the foundation upon which the true health and safety risk of site could be evaluated, the applicability of various remediation technologies examined, and the performance of implemented treatment strategies controlled.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Structural Biology of the Sequestration & Transport of Heavy Metal Toxins: NMR Structure Determination of Proteins Containing the Cys-X-Y-Cys-metal Binding Motifs**

Tech #: 226	**Date Available:**	9/14/2001	Subsurface Science-Basic Understanding		
Ref ID: 54856	**Past Investment($K):**	980	**Future Investment($K):**	0	**EMSP**

Description: The research is based on the premise that the proteins encoded in genes associated with bacterial resistance are an untapped source of reagents as well as chemical strategies for removal of heavy metal toxins from the environment. Our approach is to apply the methods of structural biology, which have previously been used primarily in biomedical applications, to bioremediation. The first and most essential step is to determine the structures of the proteins involved in binding and transport of heavy metals.

In addition to biological toxicity through damage to proteins, heavy metals are directly involved in several human diseases where transport functions have gone awry. Both Menkes and Wilson diseases are associated with improper copper metabolism, and the genes responsible for these diseases have been shown to correspond to P-type ATPases (Lutsenko and Kaplan, 1995). These large proteins have multiple repeats of a metal binding domain that is highly homologous to one found in bacterial systems. Indeed, mutations in this region of the proteins results in human diseases (Chelly et al., 1993; Mercer et al. 1993). Further, a possible connection has been found between the mercury in dental amalgam fillings and antibiotic resistance of bacteria that cause human infectious diseases (Summers et al. 1993). The genes that protect the bacteria against mercury are on a plasmid along with those for antibiotic resistance, and oral and intestinal bacteria have been found to have increased resistance to both mercury and antibiotics following the placement of dental fillings. Since small amounts of mercury are constantly released from dental fillings, the selection of mercury resistant bacteria possessing genes for the detoxification system may contribute to medically important antibiotic resistance in humans.

The immediate focus of our research is on the structural biology of proteins responsible for the binding and transporting of metals across across membranes. Once the structures of these proteins are determined, it should be possible to re-engineer them using both site directed and random mutagensis methods to optimize their functions, alter their metal binding specificities, and stabilize their structures. It may then be feasible to place the altered proteins in natural or synthetic membranes to make biologically based devices for the detection and separation of mercury or other metals. It may also be feasible to place the genes for these altered, optimized proteins in plants, which will effect removal of the heavy metal toxins from the environment (Rugh et. al., 1996).

Expected Capabilities: We propose to gain insight into biological detoxification and the possibilities for protein based ex vivo bioremediation of heavy metals by determining the structures of several bacterial and human proteins that contain metal binding modules that utilize the -Cys-X-Y-Cys-motif. These proteins are as diverse as the 8 kD periplasmic mercury binding portein merP of the bacterial mercury detoxification system (Summers, 1986) and the 200 kD human heavy-metal-transporting P-type ATPases (Lutsenko and Kaplan, 1995) which contain up to six metal binding modules homologous to merP. This research is a direct outgrowth of our initial structural studies of two of the proteins of the bacterial mercury detoxification system, merP (periplasm) and merT (transport). Itrepresents a significant extension to other proteins that share the common metal binding motif, but are used in different contexts and detoxify other metals. This research has the potential to substantially enhance the possibilities for the development of protein based bioremediation of heavy metal toxins. It is highly feasible because of the extensive preliminary results obtained on merP and merT.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Characterization of Contaminant Transport by Gravity, Capillarity and Barometric Pumping in Heterogeneous Vadose Regimes**

Tech #: 229	**Date Available:**	2/28/2001	Subsurface Science-Basic Understanding		
Ref ID: 54950	**Past Investment($K):**	1200	**Future Investment($K):**	0	**EMSP**

Description: Many releases of chemical solvents or DNAPLS occur at the surface causing the vadose layer to be the first part of a hydrologic system to interact with the contaminant. As the entry point of these chemicals into a groundwater system, the vadose zone can become a long-term source function for contamination that is metered by natural processes into the underlying saturated zone for further dispersal. However, a contaminant plume does not remain unaffected by the surrounding unsaturated soil. Heterogeneous vadose regimes, such as those containing fractures or other permeability heterogeneities, are the sites of complex interactions between the atmosphere and groundwater. When a volatile contaminant exists as free product or in dissolved form in the vadose environment, upward transport can occur with the contaminant ultimately being vented as a vapor into the atmosphere. It is known that partitioning of a liquid contaminant into the vapor phase can be a very effective means of decontamination. The subsequent transport of the vapor occurs naturally and can be enhanced, for example, by the anisotropy resulting from fractured-matrix-flow paths as well as by certain heterogeneity distributions. Several stages in the transport process are involved in going from a volatile, liquid state contaminant to a contaminant vapor vented at the surface.

Expected Capabilities: In a three-year effort, we will investigate the detailed nature of each of these stages of transport in the vadose zones of fractured and heterogeneous regimes with the (1) aid of existing data, (2) new field studies involving dissolved tracer gases and (3) 3-D diagnostic computer simulations that provide a framework to interpret our observations. We will emphasize determining the impact of features specific to a site, that is, the local geology and hydrology, on each stage of the transport process. In particular we want to better understand how the time scales for (1) partitioning contaminants from the liquid to the vapor states and then (2) transporting the vapor out of the vadose regime are dependent on the specific character of a site. Such time-scale information will be important for determining the appropriate response to vadose zone contamination including the option of natural remediation, that is, no response. This information can also be interpreted as a baseline performance criterion for proposed soil-venting schemes. Not least, this work will result in the development of new field methods, involving the injection and analysis of dissolved rare-isotope and chemical-compound tracers, that we anticipate applying to sites at Lawrence Livermore and to the thick, fractured basalt vadose regime at the Idaho National Engineering Laboratory.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Kinetics and Mechanisms of Metal Retention/Release in Geochemical Processes in Soil

Tech #: 230	**Date Available:**	9/1/2000	Subsurface Science-Basic Understanding		
Ref ID: 55014	**Past Investment($K):**	362	**Future Investment($K):**	0	**EMSP**

Description: Remediation of soils polluted with heavy metals is a major challenge facing our nation. This is especially so at many DOE facilities and other superfund sites. In many cases, speciation of the metals is inaccurate and difficult and the mechanisms by which the metals are retained/released in soils over long times are poorly understood. Consequently, the long-term fate of metals in soils cannot be precisely predicted and often, the remediation recommendations and techniques that are employed to clean up soils may be ineffective or unnecessary. The experiments will involve using various kinetic and isothermic sorption equations as models to describe the data thus acquired. The spectroscopic methods will involve using extended x-ray absorption fine structure spectroscopy (EXAFS) and Fourier Transform Infrared Spectroscopy (FTIR). The data generated from the proposed study will assist in designing better remediation strategies to effectively clean up toxic heavy metal contaminated soils at DOE facilities and other superfund sites.

Expected Capabilities: We are proposing work to generate basic knowledge on the kinetics and mechanism(s) of heavy metal retention/release by soil mineral colloids as affected by inorganic anion. The nature of the interaction of Cd(II), Co(II), Cr(VI), Cu(II), Ni(II) and Pb(II) with pure soil minerals and extracted soil clays will be investigated. The colloids will be characterized in terms of surface area, surface charge and surface site density. They will be used to study the effect(s) of pH, phosphate rate, and temperature on metals retention/release

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Colloid Transport and Retention in Fractured Deposits

Tech #: 231

Ref ID: 55036

Date Available:	1/31/2000	Subsurface Science-Basic Understanding	
Past Investment($K):	1100	**Future Investment($K):** 0	**EMSP**

Description: A series of field-scale and laboratory-scale experiments, using both natural undisturbed samples and simple one-dimension "artificial fractures", are proposed to investigate the influence of physical and chemical factors on the transport of colloids in fractured materials (weathered shale saprolite and unweathered shale). The experimental results will be assessed using a computer model(COLFRAC) developed to simulate colloid transport in fractured materials. The overall goal is to assess the relative influence of chemical and physical factors expected to influence colloid transport in fractured materials and investigate strategies for predictive simulation at the field scale.

Expected Capabilities: The overall goal is to assess the relative influence of chemical and physical factors expected to influence colloid transport in fractured materials and investigate strategies for predictive simulation at the field scale. The experimental methods each operate at different physical/geological scales and can be used with different degrees of experimental control. This allows testing of hypotheses in a relatively simple setting in the laboratory where individual chemical or colloidal characteristics can be varied, and then the results compared with field-scale experiments where the influence of realistic geologic heterogeneity can be incorporated. Understanding the processes that control colloid behavior will increase confidence with which colloid-facilitated contaminant transport can be predicted and assessed at various contaminated DOE sites. An added benefit is the expectation that this work will yield novel techniques to either immobilize colloid-bound contaminants in-situ, or mobilize colloids for enhancing remedial techniques such as pump-and-treat and bioremediation.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Quantifying Silica Reactivity in Subsurface Environments: Controls of Reaction Affinity and Solute Matrix on Quartz and SiO₂Glass Dissolution Kinetics**

Tech #: 232

Ref ID: 55042

Date Available:	9/14/2003	Subsurface Science-Basic Understanding		
Past Investment($K):	359	**Future Investment($K):**	0	**EMSP**

Description: There are a number of important motivations for quantifying SiO2 reactivity in the fluids of subsurface environments. First, quartz and silica glass are the compositional end-member crystalline and amorphous oxides to the large classes of silicate minerals and glasses. Second, an understanding of fundamental controls on the reactivity of simple Si≡O bonded phases establishes baseline behavior for silica phases widely found in waste storage environments and the host rock silicate minerals. These minerals comprise >90% of the earth's crust and dominate virtually every repository rock-water system. Third, complex silicate glasses will be the front line of defense in containing radioactive wastes in both interim and long-term storage strategies. However, we have little quantitative understanding of pure SiO2 reactivity in the solutes of natural and perturbed groundwaters even though current EM strategy calls for dispersal of waste into silica-based glass materials.

Using an experimental approach which integrates techniques from surface science and geochemical kinetics, this study will measure the dissolution rate of quartz and silica glass in a series of single and mixed solute solutions over a range of variable pH and temperature. Rates will be measured over a range of reaction affinities by adjusting the steady state silica concentration produced during the dissolution reactions. These data will allow us to construct a comprehensive quantitative model of solute controls on the reactivity of crystalline and glassy SiO2. The kinetic portion of the study will be conducted in parallel with in situ and ex situ surface sensitive analyses of selected samples/conditions. Findings will establish quantitative relationships between silica reactivity and a number of solution chemistries which have never been investigated or are presently understood in only a qualitative sense. Further, they will allow us to test the hypothesis that the solvation properties of dissolved species govern silica reactivity in a systematic and predictable way. If valid, we may be able to develop a powerful predictive tool for accurately estimating the influence of complex solute chemistries found in subsurface environments on silica reactivity and durability.

Expected Capabilities: An immediate goal of this OER/OEM initiative is the development of a predictive framework of kinetic data for mineral-solution reactions that accurately describes the current and future behavior of earth systems. Reaction rates and mechanisms are essential elements in deciphering mineral/material reactivity trends within compositional series or across a matrix of complex solution compositions. The goal of the research addresses this gap in our current understanding by quantifying the reactivity of crystalline and amorphous SiO2 phases in the complex fluids of natural systems.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Behavior of Dense, Immiscible Solvents in Fractured Clay-Rich Soils**

Tech #: 233	**Date Available:**	9/14/2000	Subsurface Science-Basic Understanding		
Ref ID: 55083	**Past Investment($K):**	600	**Future Investment($K):**	0	**EMSP**

Description: A series of laboratory-scale experiments on the behavior of dense, immiscible solvents (commonly referred to as DNAPL's) in large diameter, undisturbed columns of fractured clay till and highly weathered and fractured shale saprolite are proposed. The lab studies will focus on the influence of fracture aperture/spacing/distribution and/or matrix porosity on factors such as DNAPL entry pressures, distribution of DNAPL residual, dissolution of residual and diffusion into the high porosity matrix. These results will be compared to field-scale investigations of existing DNAPL contamination at several sites in these same materials. Information from the laboratory and field studies will be compared to results of mathematical simulations using models that have been recently developed to specifically examine the problem of DNAPL's in fractured, high porosity deposits.

Previous theoretical investigations and a few preliminary laboratory experiments indicate that DNAPL behavior in these types of deposits will be dramatically different than in granular deposits, influencing both assessment/monitoring and potential for remediation of DNAPL contamination.

Expected Capabilities: The research will systematically examine key factors involved in DNAPL behavior in fractured, high porosity deposits and has the potential to substantially improve our understanding and capability of dealing with such contamination.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: New Permeameters for In Situ Characterization of Unsaturated Heterogeneous Permeability

Tech #: 235	**Date Available:**	9/14/2000	Subsurface Science-Basic Understanding		
Ref ID: 55109	**Past Investment($K):**	612	**Future Investment($K):**	0	**EMSP**

Description: Thick unsaturated zones underlie many DOE landfills, industrial areas, and waste storage sites in the western United States (U.S.) and are the primary pathway for contaminants to migrate into underlying aquifers. The spatial variability of unsaturated permeability in these heterogeneous geologic materials directly influences the movement of water and non-aqueous phase liquids (NAPL's), precluding meaningful modeling of contaminant transport for risk assessment or remediation design. In unsaturated materials, the influence of heterogeneity on flow and transport processes is amplified by capillary forces, because permeability is a function of both geologic heterogeneity and the fluid saturation. Poor characterization of heterogeneity may lead to ineffective remedial designs and increased risk, requiring subsequent additional remedial actions at increased cost and time. There are techniques that incorporate site-specific heterogeneity into a probabilistic risk framework for decision analysis, but they cannot be applied to the unsaturated zone with confidence. It is presently not possible to collect the large number of data they need to accurately define the spatial correlation structure of unsaturated permeability. Laboratory methods for estimating the unsaturated permeability are expensive, time-consuming, and may not yield results representative of heterogeneous field conditions.

Expected Capabilities: TThis project is aimed at the design, development and testing of new rapid, and cost effective field methods for estimating in situ unsaturated permeability.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Hydrologic and Geochemical Controls on the Transport of Radionuclides in Natural Undisturbed Arid Environments as Determined by Accelerator Mass Spectrometry**

Tech #: 236	**Date Available:**	1/31/2000	Subsurface Science-Basic Understanding		
Ref ID: 55148	**Past Investment($K):**	1563	**Future Investment($K):**	0	**EMSP**

Description: Currently, the scientific understanding of these parameters cannot sufficiently meet the requirements for at least two determinations necessary for environmental management in the United States: moisture flux through unsaturated soils, and contaminant radionuclide migration in the far-field environment. The proposed radionuclide measurements will be made using newly developed techniques employing accelerator mass spectrometry (AMS), which provides the required analytical sensitivity such that this work can be conducted for the first time. The research is composed of five components: (1) developing the AMS analytical methods for 90Sr, 93Zr, and 99Tc, and improving AMS methods for 36Cl and 129I; (2) using 36Cl and elemental chlorine analyses from samples collected from a shallow-zone trench and an existing deep-zone (450 meter) drill core to define moisture flux throughout a thick vadose zone in southern Nevada; (3) measuring the distribution of 90Sr, 93Zr, 99Tc, and 129I relative to the defined moisture flux in the shallow vadose zone (where these nuclides occur due to atmospheric nuclear testing); (4) developing a numerical model based on these data that simulates the transport of these radionuclides using a flow-and-transport computer code previously developed at LLNL; and (5) using this numerical model and the moisture flux information obtained from the deep core to simulate the behavior of 90Sr, 93Zr, 99Tc, and 129I in the deep vadose zone.

Expected Capabilities: We propose to identify and quantify the geochemical parameters controlling the migration of key radionuclides (36Cl, 90Sr, 93Zr, 99Tc, and 129I) in undisturbed soils of the shallow and deep vadose zone. Our investigations in the shallow-zone, where the relationship between nuclide concentration and soil characteristics (composition, texture) can be identified, are expected to greatly improve our understanding of the relationship between chlorine-36Cl distribution and moisture flux. The work on the deep-zone, and the resulting numerical model, is expected to provide a much clearer understanding of the potential for radionuclide transport far away from the contaminant release point, in an environment that is otherwise natural and undisturbed (i.e., in the far-field environment). The radionuclides targeted in this study were distributed globally during the era of atmospheric nuclear testing, and occur in virtually all geological and biological environments. Our development of ultrasensitive AMS techniques for their detection in small samples will provide the means to assess radionuclide migration in most of these environments. This will result in a far greater understanding of potential health risks in the far-field environment, where the public is most likely to come into contact with contaminants. The targeted radionuclides are not only themselves common contaminants, but also are representative of classes of radionuclides and heavy metals that exhibit similar migration behavior. The models developed in this research will therefore furnish a foundation for a wide variety of contaminant migration assessments.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Aquifer Transport of Th, U, Ra, and Rn in Solution and on Colloids**

Tech #: 238	**Date Available:**	9/14/2000	Subsurface Science-Basic Understanding		
Ref ID: 55284	**Past Investment($K):**	500	**Future Investment($K):**	0	**EMSP**

Description: The study will obtain information on the natural radionuclides provided to groundwater throughout an aquifer system that will be used to constrain quantitatively the transport in groundwater and removal to host formations of radionuclides that potentially may reach the recharge zones of these aquifers.

The goal of the proposed work is to investigate the fundamental controls on natural radionuclide migration in specific aquifers by integrating aquifer sample analyses, focussed laboratory experiments, and field observations of two aquifer study sites. This will include analyses of particles and colloids as well as 'dissolved' species. The work will use standard decay counting methods for determining concentrations of the short-lived nuclides and high precision mass spectrometry to measure the long-lived nuclides. The project will focus on obtaining the following:

Measurements of radionuclide concentrations in groundwaters and changes in concentrations along groundwater flow lines as water chemistry evolves.
Measurements of the proportion of radionuclides transported by colloids and particles.
Laboratory measurements of the rate of recoil supply of radionuclides to groundwater.
Measurement of the distribution of parent elements within the aquifer rock to determine the controls on radionuclide recoil and dissolution inputs to groundwater.
Calculation of radionuclide removal and retardation rates based upon input rates and groundwater evolutionary history.
Laboratory measurements of the rates of removal by adsorption of the radionuclides onto aquifer host rocks, and comparison of this data with calculated aquifer removal rates.
Model calculations and predictions of the transport behavior and rates of migration of waste radionuclides that potentially may reach the recharge zones of sandy and limestone aquifers.

Expected Capabilities: The purpose of this study is to investigate the behavior of naturally occurring U, Th, Ra, and Rn isotopes in groundwater and to utilize these elements as natural analogues for waste radionuclides in predicting migration behavior in potentially impacted aquifers.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **A Hybrid Hydrologic-Geophysical Inverse Technique for the Assessment and Monitoring of Leachates in the Vadose Zone**

Tech #: 239	**Date Available:**	3/15/2001	Subsurface Science-Basic Understanding		
Ref ID: 55332	**Past Investment($K):**	2024	**Future Investment($K):**	0	**EMSP**

Description: The Hybrid Hydrologic-Geophysical Inverse Technique (HHGIT) combines electrical resistivity tomography (ERT) to geophysically sense a 3D volume, statistical information about fabric of geological formations, and sparse data on moisture and contaminant distributions. Combining these three types of information into a single inversion process will provide much better estimates of spatially varied hydraulic properties and three-dimensional contaminant distributions than could be obtained from interpreting the data types individually. Furthermore, HHGIT will be a geostatistically based estimation technique; the estimates represent conditional mean hydraulic property fields and contaminant distributions. Thus, this method will also quantify the uncertainty of the estimates as well as the estimates themselves. The knowledge of this uncertainty is necessary to determine the likelihood of success of remediation efforts and the risk posed by hazardous materials. Controlled field experiments will be conducted to provide critical data sets for evaluation of these methodologies, for better understanding of mechanisms controlling contaminant movement in the vadose zone, and for evaluation of the HHGIT method as a long term monitoring strategy.

Expected Capabilities: It is the objective of this proposed study to develop and field test a new, integrated Hybrid Hydrologic-Geophysical Inverse Technique (HHGIT) for characterization of the vadose zone at contaminated sites. This fundamentally new approach to site characterization and monitoring will provide detailed knowledge about hydrological properties, geological heterogeneity and the extent and movement of contamination.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Long-term Risk from Actinides in the Environment: Modes of Mobility

Tech #: 242	**Date Available:**	12/31/2001	Subsurface Science-Basic Understanding	
Ref ID: 60015	**Past Investment($K):**	900	**Future Investment($K):** 0	**EMSP**

Description: The mobility of actinides in surface soils is a key concern at several DOE facilities in arid and semiarid environments, including Rocky Flats, Hanford, Nevada Test Site, Idaho National Engineering and Environmental Laboratory, and Los Alamos National Laboratory and the Waste Isolation Pilot Plant (WIPP). Currently, Pu mobility is a high visibility issue at Rocky Flats and Hanford, with current litigation clean-up decisions pending on assessment of the risks resulting from the long-term mobility of Pu. Key sources of uncertainty in assessing Pu mobility are the magnitudes of mobility resulting from three modes of transport: (1) wind erosion, (2) water erosion, and (3) vertical migration. Each of these three processes depend on numerous environmental factors and they compete with one another, particularly for actinides in very shallow soils (~ 1 mm).

Tracers will be applied to plots and their redistribution will be measured over time. Wind erosion will be quantified using spatially-distributed aerosol measurements, including finely time-resolved measurements, and will be correlated with meteorological and ground cover conditions. Water erosion will be quantified using rainfall simulator experiments in the field to measure vertical and horizontal changes in the tracer distribution. Vertical migration will be studied using tracers on and off of the rainfall simulation plots and will be measure through time to quantify the effects of various biological and weathering processes.

Expected Capabilities: The overall goal of the study is to quantify the mobility of soil actinides from all three modes. We propose to conduct a set of studies on four plots and obtain additional measurements at adjacent locations at each of three DOE facilities where actinide kinetics are of concern: Rocky Flats, Hanford, and WIPP. The results will be integrated using a modeling approach, building on existing code and modifying the predictions based on experimental results.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Fast Flow in Unsaturated Coarse Sediments

Tech #: 259	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70069	**Past Investment($K):**	300	**Future Investment($K):**	150	**EMSP**

Description: Problems of contaminant transport in the vadose zone are very complex because of subsurface heterogeneity, waste-sediment reaction induced alteration of sediment properties, and our lack of understanding of certain basic processes even in the absence of heterogeneity and reactions. This proposal focuses on an important area in need of basic understanding; flow in unsaturated, very coarse sediments. We start by identifying problems with applying existing pore-scale conceptual models for unsaturated flow to very coarse-textured sediments, through which the importance of film flow emerges. Recent insights into the physics of film flow on unsaturated fracture surfaces are then applied to the case of film flow on gravel surfaces. These previous measurements and recent calculations indicate that fast flow can occur in very coarse-textured media, at low saturations. The proposed research is designed to further test these results through a series of macroscopic and microscopic experiments on very coarse sediments having a variety of surface roughnesses and wettabilities. The macroscopic experiments consist primarily of soil physics methods modified to obtain bulk unsaturated hydraulic properties of coarse sediments in the energy range most relevant to fast, unsaturated flow. This energy range spans matric potentials from about -10 to 0 kPa. The macroscopic measurements will provide valuable additions to the currently sparse data on unsaturated hydraulic properties of very coarse sediments. The microscopic measurement of film flow and unsaturated pore-scale hydrodynamics will provide mechanistic explanations for the observed macroscopic properties and processes. To better understand transient flow across coarse textural interfaces and also explore limitation of capillary barrier performance, experiments will also be conducted on texturally stratified systems. This set of investigations will result in a comprehensive understanding of fast flow through unsaturated coarse sediments, integrating microscale mechanisms with bulk system behavior. Progress in predicting vadose zone contaminant transport and remediation requires this understanding.

Expected Capabilities: This research proposal was developed to improve our understanding of the physics of unsaturated flow in coarse- to very coarse-textured sediments, and through this meet practical needs related to contaminant transport in such vadose environments. This is a critical area for improving our basic understanding of vadose zone flow and transport because it contains aspects that are beyond the realm predictable by classical Miller-Miller scaling analyses. In particular, very coarse-textured media can sustain high flow rates at low saturations, and do so via film flow rather than by flow through an interconnected network of saturated pores. Thus, the physics of fast flow processes in unsaturated very coarse media is fundamentally different from that traditionally recognized in finer textured sediments. Developing an understanding of unsaturated flow in very coarse media is also essential for pragmatic purposes including the management of severely contaminated DOE sites, the use of coarse granular media in engineering subsurface waste isolation systems, and the fact that such sediments can support very fast flow and transport. Some of the most badly contaminated sites under DOE custody are found at Hanford, Washington, where much of the vadose zone consists of gravels and gravelly sands. Without understanding the basic processes unique to fast, unsaturated flow in such coarse sediments, our abilities to predict contaminant transport in such environments will remain poor. Such understanding is also needed because layers of unsaturated coarse granular sediments are now being used for vadose zone waste isolation in engineered "capillary barriers". Such systems work best when infiltration is low and uniformly distributed, without significant preferential flow. Deep migration of contaminants at Hanford and other sites through texturally stratified vadose zones provide "natural" analogs showing that the capillary barrier principle has severe limitations, especially when seepage originates for very localized sources such as that expected from leaking tanks. Here again, we need to better understand the physics of unsaturated flow in very coarse granular media in order to improve our ability to isolate wastes in the vadose zone.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Effects of Fluid Distribution on Measured Geophysical Properties for Partially Saturated, Shallow Subsurface Conditions**

Tech #: 260 | **Date Available:** 9/14/2002 | Subsurface Science-Basic Understanding

Ref ID: 70108 | **Past Investment($K):** 500 | **Future Investment($K):** 250 | **EMSP**

Description: Effective in situ remediation requires a knowledge of subsurface porosity, permeability, and fluid saturation. Estimation of hydrogeologic properties using improved geophysical imaging and interpretation is faster, cheaper, and less invasive than drilling. Methods for interpretation of geophysical field data can be improved by using controlled laboratory experiments to measure geophysical properties as functions of saturation, pressure, and soil composition, and then using rock physics theories to relate these measurements to hydrogeologic properties and to generalize results to the field scale.

We will conduct controlled laboratory ultrasonic experiments on partially saturated soil samples including sand, sand-clay mixtures, and soil samples from a DOE Environmental Management site such as the Hanford site in Washington state or the Idaho National Engineering and Environmental Laboratory (INEEL) site. We will use x-ray computed microtomography to image fluid distribution and soil composition in our samples. We will combine these data with available laboratory measurements of electrical properties for similar samples, such as laboratory measurements of the dielectric constant. We will use rock physics theories to develop relationships between the laboratory measurements and porosity, saturation, and fluid distribution, to improve interpretation of geophysical field data such as cross-hole seismic and ground-penetrating radar measurements.

Expected Capabilities: The objective of this work is to develop relationships between laboratory measured geophysical properties and porosity, saturation, and fluid distribution for partially saturated soils. Results will improve interpretation of geophysical data collected in the field for characterizing in situ soils in the subsurface and fill materials such as sands used in capillary barriers.

Results of this proposed work can be applied to improving interpretation of geophysical field measurements used to characterize the subsurface and monitor remediation in the vadose zone at contaminated sites such as Hanford or INEEL. Improved subsurface characterization is essential to the Environmental Management mission, particularly for the subsurface contamination and tanks focus areas, and has direct relevance to needs for remediation of carbon tetrachloride and hexavalent chromium in soils in the vadose zone at Hanford, and to needs for improved technologies for detection and delineation of burial ground contents and subsurface geological boundaries in burial ground sites and liquid waste disposal sites at Hanford. The research results also may be relevant to the need for delineating and verifying removal of dense, non-aqueous phase liquids (DNAPLs) at various sites; the need for improving understanding of contaminant transport in a fractured rock vadose zone at INEEL; and possible monitoring of capillary barrier performance at Hanford in the future.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **The Influence of Calcium Carbonate Grain Coatings on Contaminant Reactivity in Vadose Zone Sediments**

Tech #: 262	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70121	**Past Investment($K):**	1070	**Future Investment($K):**	230	**EMSP**

Description: This project will explore the behavior of calcium carbonate grain coatings including how they form and dissolve (e.g., natural and waste fluid induced), their reactivity toward contaminants under water-saturated and unsaturated conditions, their impact on the reactivity of the mineral substrate, and their in-ground composition and minor element enrichment. Our scientific focus will be on the influence of the coatings on, 1.) surface coordination or co-precipitation reactions, and 2.) electron transfer reactions that can result in the immobilization of redox-sensitive contaminants. Modern surface- and bulk-sensitive structural and imaging methods including X-ray absorption spectroscopy, scanning probe microscopy, photoelectron spectroscopies, and others will be applied in concert with judiciously designed model systems such as epitaxially grown surfaces of known crystallographic orientation and structure to provide a rigorous molecular and microscopic understanding of the controlling reactions of target contaminant ions with carbonate-coated mineral surfaces.

Expected Capabilities: The goal is to provide an improved understanding of contaminant sequestration/immobilization reactions that can be scaled to macroscopic reactive transport models used to forecast contaminant migration. Model system studies will be linked with parallel spectroscopic, microscopic, and macroscopic investigations of calcareous Hanford sediments, to provide basic scientific information for the remediation/closure of Hanford and other DOE sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Collaboration: Interfacial Soil Chemistry of Radionuclides in the Unsaturated Zone**

Tech #: 263	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70126	**Past Investment($K):**	688	**Future Investment($K):**	59	**EMSP**

Description: Macroscopic experiments will be conducted in batch and column modes. Initial experiments will involve model clays to facilitate mechanistic investigations, and then extended to Hanford soils. Distribution of radionuclides among free, aqueous-humic-bound, and mineral (illite, vermiculite, smectite, and kaolinite)-humic-bound forms in heterogeneous systems will be determined using equilibrium dialysis. The role of high-affinity sites (e.g., siloxane, frayed edge sites [FES]) in influencing radionuclide fixation with contaminant aging will be evaluated using isotopic exchange and desorption (infinite bath) techniques. Changes in the density/accessibility to FES caused by hydroxy/NOM coatings on clay surfaces will also be investigated. XRD, FTIR, and NMR analyses will permit monitoring dynamic dissolution-reprecipitation disequilibrium induced by high pH and Al conditions. NMR investigations of sorption interactions will involve the use of cross polarization (CP), rotational-echo double-resonance (REDOR), and double- and triple-resonance transfer of populations by double-resonance (TRAPDOR) techniques. These new methods will provide direct information on ion exchange dynamics and proximity in space of 133Cs and interacting mineral framework species. Details of the local structural environment around the sorbed radionuclide and nature of the sorption complex (e.g., inner versus outer sphere) will be obtained using X-ray absorption spectroscopy.

Expected Capabilities: Rates of sorption/desorption and conditional selectivity (Kex) and partition (Kd) coefficients that can be used to quantify the sorption/exchange reaction of radionuclides with minerals will be determined. These values will be obtained as a function of aqueous chemistry representing the continuum between concentrated waste liquor and dilute soil solution end-members and also for various sorbent conditions (i.e., pristine, weathered and coated clays, whole Hanford soils). Mechanisms of interactions (strength of sorption, type of sorption sites) will be elucidated at a molecular level using methods developed in our laboratories.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Speciation, Mobility and Fate of Actinides in the Groundwater at the Hanford Site**

Tech #: 264	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70132	**Past Investment($K):**	900	**Future Investment($K):**	100	**EMSP**

Description: We suggest that there are gaps and inconsistencies in our understanding of actinide behavior in groundwater due to the widely varying properties of Pu from different sources and due to variations in sampling and analytical methodologies. It is our intent to sample across defined contaminant plumes at the Hanford Site for Pu and other actinides. Samples are collected using a "micro-purge" low pumping rate technique and directly separated into truly dissolved and colloidal size classes with an ultra-clean cross-flow filtration (CFF) system. Pu redox samples are separated immediately in the field and ancillary samples are also carefully collected for supporting organic and basic geochemical analyses. High sensitivity thermal ionization mass spectrometry (TIMS) is used to detect the Pu isotopes in all size and redox fractions, thus providing information not only on Pu concentrations but on the Pu source, which can strongly influence Pu speciation and mobility. The combination of these state-of-the-art procedures and the demonstrated care taken to process these samples ensures that the data represent the original in-situ speciation.

Expected Capabilities: The results of such a careful basic research program would: i) provide the basis for accurate modeling and prediction of actinide transport; ii) allow for remediation strategies to be planned that might use in-situ manipulations of geochemical variables to enhance (for extraction) or retard (for immobilization) Pu mobility in the vadose/groundwater zone, and iii) identify specific Pu sources and the extent of far field, or long-term migration of actinides in groundwaters. This new knowledge is essential to ensure continued public and worker safety at the DOE sites and the efficient management of cleanup and containment strategies.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Colloid-Facilitated Transport of Radionuclides Through the Vadose Zone

Tech #: 265	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70135	**Past Investment($K):**	700	**Future Investment($K):**	0	**EMSP**

Description: The objectives of this proposed project are to study three major processes responsible for colloid-facilitated transport: (1) formation and mobilization of colloids, (2) association of contaminants with colloidal particles, and (3) co-transport of colloids and contaminants in the vadose zone. We specifically consider chemical and geochemical conditions at the Hanford site. The radionuclide Cs is selected as a model contaminant. Soil or sediment samples representative of the porous material under waste storage tanks will be collected at the Hanford site. Formation of colloids will be studied in batch systems by reacting solutions typical for tank waste with vadose zone materials and with solutions expected at equilibrium with soil material. Colloids will be separated and characterized in terms of size, structure, composition, and surface charge characteristics. The interactions of Cs with colloidal particles isolated from the previous step will be investigated with batch sorption experiments and spectroscopic techniques. Transport and co-transport of colloids and the radionuclide Cs will then be studied with a series of laboratory column experiments using repacked Hanford sand material. Experiments will be carried out under unsaturated, steady-state as well as transient water flow to study the effect of water content on colloid transport. Magnetic Resonance Imaging will be used to visualize colloidal movement inside the porous medium. Sorption studies and column outflow data will be analyzed with numerical models to elucidate the relevant mechanisms responsible for contaminant sorption as well as colloid and radionuclide transport. Sorption and reaction models will be combined with transport models to quantitatively describe the column experiments. The results of the proposed research will lead to a better understanding of colloid-formation, colloid-contaminant-soil interactions, colloid migration, and colloid-facilitated transport in the vadose zone.

Expected Capabilities: The results of the proposed research will lead to a better understanding of colloid-formation, colloid-contaminant-soil interactions, colloid migration, and colloid-facilitated transport in the vadose zone. The experiments proposed use conditions specific to the Hanford site, and the results are therefore directly applicable to clean-up strategies and procedures for Hanford contamination problems. We expect to provide conclusive evidence under what conditions, if any, colloid-facilitated transport can be expected at the Hanford site, and what the quantitative magnitude of this transport process will be.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Spectroscopic and Microscopic Characterization of Contaminant Uptake and Retention by Carbonates in Soils and Vadose Zone Sediments**

Tech #: 266 | **Date Available:** 9/14/2002 | Subsurface Science-Basic Understanding

Ref ID: 70146 | **Past Investment($K):** 667 | **Future Investment($K):** 100 | **EMSP**

Description: The release and migration of toxic metals and radionuclides within the subsurface and vadose zones at various sites over the DOE Complex pose serious technological challenges for remediation. The design and implementation of cost-effective remediation strategies require knowledge of the factors that govern contaminant mobility and reactivity within their host materials. Calcium carbonate, resulting from pedogenic processes, is an important component of soils and vadose-zone materials at the Hanford Site, where it coats grains and occurs as a massive caliche layer at depth.

Adsorption and desorption experiments for target contaminants on calcite will be conducted using radioisotope and high-precision gamma-counting methods to determine both the kinetics and extents of uptake from solutions over a pH range relevant to site conditions. Desorption will test the tendency for long-term retention of contaminants on calcite. Because existing studies suggest that adsorption onto calcite results in co-precipitation, which would have a major influence on potential re-release, it is essential to determine the chemical state of the adsorbed metals, i.e., its speciation. Contaminant speciation will be determined in situ using X-ray absorption fine structure (XAFS) spectroscopy of "wet slurries" as a function of duration of adsorption and surface coverage. This element-specific technique provides information on oxidation state, molecular formula and structure, and identity of ligands, and allows distinction between inner-sphere and outer-sphere type surface complexes as well as between co-precipitation and surface precipitation. Separate co-precipitation experiments with target contaminants will allow an assessment of the effectiveness of uptake during crystallization of calcite, which is favored in the soil and vadose zone as a result of periodic wetting and drying, and also in response to the highly alkaline waste fluids. XAFS spectroscopy will again be used to confirm speciation.

Expected Capabilities: We propose a collaborative project to characterize the uptake and retention of contaminants (Co, Cs, Pb, Sr, Cr, and U) on calcium carbonate (calcite), with a focus on conditions and materials relevant to this site. The research plan calls for detailed microscopic and spectroscopic characterization of carbonate coatings and caliche from the Hanford Site, combined with an assessment of the heterogeneity of reactive surface sites that could influence contaminant uptake properties or long-term retention. This will rely on icroscopic study as well as mineralogic and geochemical characterization. Spatially resolved X-ray fluorescence and X-ray absorption spectroscopy (micro-XRF/XAS) as well as X-ray photoelectron spectroscopy (XPS) will be used to map the distribution of contaminant reaction products after exposure to natural and model carbonate substrates. These results will have direct application for assessing the reactive fraction of available surface area on carbonates from the affected site.

The results of this comprehensive study will provide detailed information on contaminant speciation, physical and chemical properties of subsurface carbonate phases, and the reactions involving calcium carbonates that occur in the subsurface zone for a site relevant to DOE goals. These are essential components of models necessary for predicting contaminant mobility and for designing effective technologies for the recovery or immobilization of contaminants.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Transuranic Interfacial Reaction Studies on Manganese Oxide Hydroxide Mineral Surfaces**

Tech #: 268	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70176	**Past Investment($K):**	500	**Future Investment($K):**	250	**EMSP**

Description: Several DOE sites have been contaminated by transuranic radionuclide (TRU) discharges. Of these TRU, neptunium and plutonium are highly toxic and potentially mobile in the vadose zone. Modeling predictions of their potential hazard to humans require reliable estimates of migration rates. Manganese oxide/hydroxide minerals, present as minor phases, can preferentially sequester TRU over iron oxide/hydroxide minerals. The interactions between TRU and manganese oxyhydroxide minerals that determine the retardation, immobilization, and mobilization in the vadose zone are poorly understood.

Expected Capabilities: Fundamental knowledge on the interfacial reactions of neptunium and plutonium with manganese oxide and hydroxide mineral surfaces relevant to contaminant transport in the vadose zone will be provided. Key thermodynamic and kinetic parameters governing the sorption of aqueous neptunium and plutonium species in defined oxidation states on characterized mineral surfaces as a function of pH, actinide concentration, and ionic strength will be determined on six manganese oxyhydroxide minerals. The influence of ethylenediaminetetraacidic acid (EDTA), microorganisms, and iron oxide/hydroxide minerals on sorption will also be determined for one site-specific manganese system. Surface complexation models will be developed to provide prerequisite information for reactive transport modeling that will lead to an improved basis for predicting TRU migration in the vadose zone to nearby water supplies.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Technetium Attenuation in the Vadose Zone: Role of Mineral Interactions**

Tech #: 269	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70177	**Past Investment($K):**	630	**Future Investment($K):**	315	**EMSP**

Description: Approximately 4.5 x 108 L of liquid waste containing 930 Ci of 99Tc from uranium recovery processing were discharged directly to the ground at the Hanford Site from 1953 to 1958. As a result, the entire soil column beneath many of the disposal sites became saturated. Technetium is anticipated to be highly mobile and to readily migrate to groundwater. However, mass balance calculations indicate that more than 80% of the 99Tc released to the subsurface environment at Hanford may not have entered the groundwater. It is hypothesized that Tc reduction through surface-mediated reactions with FeII-containing minerals may have resulted in precipitation of low solubility TC solids, effectively immobilizing TC in the vadose zone and accounting for this discrepancy.

Published sorption studies demonstrate that limited adsorption of TcVII on FeII minerals occurs under oxic conditions. The immobilization of Tc under oxic conditions requires surface-mediated reduction of TcVII to low solubility TcIV species that precipitate. Thermodynamic data for the TcIV species and solubility limiting solids under these conditions are not available. Lack of fundamental data on these aspects seriously impairs the validity of risk assessment and the efficiency of remediation efforts.

Expected Capabilities: The proposed research will determine the mechanisms of surface-mediated reduction/precipitation reactions of Tc on FeII-containing mineral surfaces, the composition of these precipitates, and build a thermodynamic database for the solubility-limiting phases and aqueous species. These results can be directly utilized in contaminant transport
modeling in the vadose zone and for the design of appropriate remedial strategies for Tc.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Quantifying Vadose Zone Flow and Transport Uncertainties Using a Unified, Hierarchical Approach

Tech #: 271	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70187	**Past Investment($K):**	400	**Future Investment($K):**	200	**EMSP**

Description: This project will develop and demonstrate a general approach for modeling flow and transport in the heterogeneous vadose zone. Following a method recently presented by Rockhold et al. [1996], the approach will use geostatistical analysis, similar media scaling, and conditional simulation to estimate soil hydraulic parameters at unsampled locations from field-measured water content data and a set of scale-mean hydraulic parameters. The method of Rockhold et al. [1996] was applied very successfully to the simulation of a controlled field experiment. However, the relatively small scale of this experiment (12 m square by 6 m deep) and the abundant and detailed site characterization data do not represent the remediation and waste management problems facing DOE.

We hypothesize that the practical utility of the method of Rockhold et al. [1996] can be enhanced by making use of recent developments in methods to estimate soil hydraulic parameters from soil physical properties and in the estimation of soil water content using geophysical techniques. Our objectives are to 1) investigate the application of indirect measurements of soil properties to the method of Rockhold et al.; 2) determine the relationships between the type of data, the quantity of data, the scale of measurement, and the uncertainty in predictions of flow and transport using this method; and 3) develop guidance for the effective application of the method at field scales common to DOE vadose zone contamination problems. We will utilize data from a recent large-scale (50 m square by 15 m deep) experiment conducted at the Maricopa Agricultural Center in Arizona. Detailed soil characterization, water content, soil water tension, and electrical resistivity measurements have been collected for two controlled infiltration experiments. We will also revisit an infiltration experiment (16 m square by 20 m deep) conducted at the Hanford Site. Soil characterization data will be collected at this site to supplement the available information.

Expected Capabilities: The results of the proposed research will provide a framework for guiding future vadose zone characterization activities at DOE sites, and an accurate, systematic approach for parameterizing models used for evaluating remediation alternatives and predicting contaminant transport and fate. The proposed research directly addresses issues of site characterization, uncertainty in vadose zone flow and transport simulations, and model validation. In addition, this research represents an innovative, low-cost approach for addressing key issues related to DOEÆs
mission to remediate contaminated sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Influence of Clastic Dikes on Vertical Migration of Contaminants in the Vadose Zone at Hanford**

Tech #: 272	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70193	**Past Investment($K):**	617	**Future Investment($K):**	233	**EMSP**

Description: This research will test the hypothesis that clastic dikes at the Hanford Site provide preferential pathways that enhance the vertical movement of moisture and contaminants through the vadose zone. Studies indicate that contaminants have migrated to greater depths at the Hanford Site than expected. This includes the possible migration of cesium in the SX Tank Farm, and the presence of Technetium, carbon tetrachloride, and other mobile contaminants in groundwater beneath the 200 Area Tank Farms. Clastic dikes occur at many location in both the 200 West and 200 East areas and have been proposed as potential pathways for vertical transport that could explain this deep migration of contaminants. However, reliable data on the dikes are scarce. Current flow and transport models of the vadose zone at the 200 Areas, including the Tank Farms, are based on relatively simple hydrogeologic models that assume horizontally layered sediments, with no preferential vertical flow paths. Given the uncertainty with regard to the properties of clastic dikes, an integrated study is needed to assess their geometry and internal properties, and their potential effect on vertical transport. To address those scientific needs, our proposed research includes field and modeling studies on the spatial distribution of clastic dikes, the hydrologic properties within dikes, and the potential effect of clastic injection dikes on fluid flow through the vadose zone.

Expected Capabilities: This research, which will be conducted at an uncontaminated site adjacent to the S-SX Tank Farm, will determine if clastic injection dikes provide fast paths for vertical transport through the vadose zone at Hanford. The study will provide models for the geometric pattern and properties of clastic dikes in the S-SX Tank Farm, which should also be suitable for other nearby Tank Farms in the 200 West Area. The scientific methodology developed in this study could also be applied to develop suitable models for other Hanford areas, such as Tank Farms in the 200 East Area, and may be applicable to modeling the effect of faults on vertical transport through sediments at other DOE sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Fate and Transport of Radionuclides Beneath the Hanford Tank-Farms: Unraveling Coupled Geochemical and Hydrological Processes in the Vadose Zone**

Tech #: 273 | **Date Available:** 9/14/2002 | Subsurface Science-Basic Understanding

Ref ID: 70219 | **Past Investment($K):** 867 | **Future Investment($K):** 343 | **EMSP**

Description: The overall goal of this research is to provide an improved understanding and predictive capability of coupled hydrological and geochemical mechanisms that are responsible for the accelerated migration of radionuclides in the vadose zone beneath the Hanford Tank Farms. The study is motivated by the technological and scientific needs associated with the long-term management of the enormous in-ground inventories of multiple contaminants at the Hanford site. Our objectives are to (1) provide an improved understanding of how lithological discontinuities within the sediments influence the propensity for preferential flow and matrix diffusion at different water contents, (2) quantify the significance of downward vertical advection, lateral spreading, and physical nonequilibrium processes on radionuclide transport under variable hydrologic conditions, and (3) quantify the rates and mechanisms of 137Cs, 235/238U, and 99Tc interaction with the solid phase under various hydrodynamic conditions and to determine how physical heterogeneities (i.e. stratification, pore regime connectivity) influence the retardation and degree of geochemical nonequilibrium during contaminant transport. The proposed work consists of two multidisciplinary tasks that seek to resolve four scientifically-rigorous hypotheses concerned with coupled hydrological and geochemical processes controlling contaminant migration in the vadose zone. Our approach involves (1) field-relevant, long-term unsaturated flow and transport experiments in undisturbed Hanford sediments, (2) multiple tracer strategies for quantifying preferential flow and nonequilibrium mass transfer processes at various water contents, and (3) a variety of novel surface analyses techniques (x-ray computed tomography, x-ray absorption spectroscopy, hyperquenching fluorescence) to quantify the distribution and chemical environment of contaminants as a function of sediment lithology and water content.

Expected Capabilities: The experimental and numerical results from this research will provide knowledge and information in previously unexplored areas of vadose zone fate and transport to support EMÆs performance/risk assessment and decision-making process for Tank Farm restoration. By unraveling fundamental contaminant transport mechanisms in complex porous media, we will provide an improved conceptual understanding and predictive capability of a variety of vadose issues within the DOE system. Further, this proposal combines DOEÆs commitment to environmental restoration with its commitment to major user facilities (Stanford Synchrotron Radiation Laboratory, Advanced Photon Source, Environmental Molecular Sciences Laboratory) and academic education.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **A Hydrologic-Geophysical Method for Characterizing Flow and Transport Processes within the Vadose Zone**

Tech #: 274	**Date Available:**	9/14/2002	Subsurface Science-Basic Understanding		
Ref ID: 70267	**Past Investment($K):**	855	**Future Investment($K):**	150	**EMSP**

Description: The proposed experiment will be conducted at the Sandia/Tech Vadose Zone (STVZ) facility where an infiltration experiment is currently being conducted to characterize flow in unsaturated media. Subsurface hydrologic conditions are being monitored using hydrological sensors as well as the electrical resistivity tomography (ERT) and cross borehole ground penetrating radar (XBGPR) geophysical methods. As deployed these two methods are complimentary in that the ERT produces full 3D estimates of subsurface properties, while the XBGPR yields only 2D images but at a higher resolution than the ERT such that finer scale processes and heterogeneities can be detected and examined. Once this infiltration has reached steady state, a hybrid hydrologic/geophysical inverse technique (HHGIT) will be employed to produce 3D estimates of hydrologic parameter distribution at the site, as well as the error associated with those estimates. A state of the art numerical transport scheme will then be employed to simulate and design transport experiments where a saline fluid is allowed to infiltrate into the subsurface at the STVZ site. The progress of field experiments will be monitored using the two geophysical methods.

Expected Capabilities: The resulting geophysical images will yield valuable information about transport processes within the vadose zone and the effect of disturbances such as unsealed wells on transport and flow in unsaturated conditions, and will provide a validation of both the numerical schemes employed here as well as other hydrologic modeling codes.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Migration and Entrapment of DNAPLs in Heterogeneous Systems: Impact of Waste and Porous Medium Composition**

Tech #: 276	**Date Available:**	9/14/2003	Subsurface Science-Basic Understanding		
Ref ID: 73732	**Past Investment($K):**	325	**Future Investment($K):**	350	**EMSP**

Description: The research proposed herein seeks to bridge the gap in knowledge between well defined systems and the complex contaminant mixtures and soils found at DOE sites. To this end, a research plan has been designed to explore the influence of DOE waste and site porous medium composition on DNAPL migration and entrapment. This research goal will be approached through a combination of laboratory and numerical experiments. Interfacial and hydraulic properties for representative DNAPL wastes and soils encompassing conditions typical of DOE sites will be measured. Results from these benchmark studies will be used to deduce mechanisms controlling system properties, and to develop regression relations and predictive procedures for their estimation. The predictive ability of such procedures will then be assessed through independent comparison between predictions and measured relations for actual DOE field soils and wastes. Experimental studies will be used to develop and refine theory and conceptual models for DNAPL fate which will be incorporated into an existing two dimensional multiphase flow and transport simulator. One- and two-dimensional DNAPL infiltration experiments will be conducted for a subset of these model wastes and soils. Comparison between infiltration data and simulator results will then be used to further assess and refine the constitutive models for interfacial and hydraulic propertied, to investigate the up-scaling of findings from batch and soil column experiments to two-dimensional systems, and to experimentally validate the simulator. The refined simulator will be used to numerically explore the influence of waste and porous medium composition on DNAPL fate in more heterogeneous systems and at larger scales.

Expected Capabilities: The accomplishment of the research proposed herein will improved our ability to quantify interfacial and hydraulic properties, and residual saturations for complex DOE wastes and soils. Furthermore, the accuracy and flexibility of numerical models will be enhanced by incorporation of constitutive models which account for spatially and temporally varying interfacial and hydraulic properties. Ultimately, this information will aid in the characterization of DNAPL waste sources and fate, improve the estimation of remediation costs, and facilitate the selection of efficient remediation strategies.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Corrosion of Spent Nuclear Fuel: The Long Term Assessment**

Tech #: 277	**Date Available:**	9/14/2003	Subsurface Science-Basic Understanding		
Ref ID: 73751	**Past Investment($K):**	217	**Future Investment($K):**	228	**EMSP**

Description: Fortunately, our experimental analysis and field studies have established that natural uranite and its alteration products are good ônatural analoguesö for the study of the corrosion of UO2 in spent nuclear fuel. We propose in this research program to address the following issues:

□What are the long-term corrosion products of natural UO2+x, uranite, under oxidizing and reducing conditions?
What is the paragensis or the reaction path for the phases that form during alteration? How is the sequence of formation related to the structure of these uranium phases and reacting groundwater composition?
□What is the trace element content in the corrosion products as compared with the original UO2+x? Do the trace element contents substantiate models developed to predict radionuclide incorporation into the secondary phases?
□Are the corrosion products accurately predicted from geochemical codes (e.g., EQ3/6) that are used in performance assessments?
□How persistent over time are the metastable phase assemblages that form? Will these phases serve as effective barriers to radionuclide release?
□Experimental results and theoretical models for the corrosion of spent nuclear fuel under oxidizing and reducing conditions will be tested by comparison to results from studies of samples from the Oklo natural fission reactors.

Expected Capabilities: Spent nuclear fuel accounts for over 95% of the total radioactivity in the radioactive wastes in the United States that require disposal, disposition or remediation. Uranium is the dominant actinide element in most of these nuclear wastes. The UO2 in spent nuclear fuel is not stable under oxidizing conditions and may be altered even under reducing conditions.

Under oxidizing conditions, uranium has a strong tendency to exist as U6+ in the uranyl molecule, UO22+. The uranyl ion reacts with a wide variety of inorganic and organic anions to form complexes that are often highly solble. The result is a rather rapid dissolution of UO2 and the formation of a wide variety of uranyl oxide hydrates, uranyl silicates and uranyl phosphates. The kinetics for this transformation are rapid and essentially instantaneous on geologic time scales.

Under reducing conditions, UO2 is stable, but may alter to U4+ compounds, such as coffinite, USiO4, depending on groundwater compositions.

Under both oxidizing and reducing conditions, the formation of new uranium phases may lead to the release or retardation of trace elements, such as the fission product elements and actinides in spent nuclear fuel. Over the long term, and depending on the extent to which the secondary uranium phases can incorporate fission products and actinides, these alteration phases become the near-field source term.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Radiation Effects on Sorption and Mobilization of Radionuclides During Transport Through the Geosphere**

Tech #: 278

Ref ID: 73762

Date Available:	3/14/2003	Subsurface Science-Basic Understanding		
Past Investment($K):	300	**Future Investment($K):**	300	**EMSP**

Description: We propose to expand our study of radiation effects on the sorption and ion-exchange capacities of clays and zeolites by applying newly designed experimental methods. The radionuclides to be studied include Cs, Sr, U, and Se. These nuclides are important because: 1) they represent a range of sorptive behavior that should bracket the behavior of most other radionuclides (except 99Tc) and 2) they are considered to make important contributions to total radiation exposures, as illustrated in the recent Total Systems Performance Assessment-Viability Assessment of the proposed repository at Yucca Mountain.

Selected clay and zeolite samples will be irradiated with high energy electrons, high energy ions and neutrons to simulate the radiation effects from a variety radioactive decay processes at a much accelerated rate using a unique combination of irradiation facilities available at the University of Michigan (the Ford Nuclear Reactor and the Michigan Ion Beam Laboratory). Ion exchange/sorption experiments will be conducted on samples irradiated to various doses to determine the impact of the radiation effects on the sorption capacity and retention of radionuclides. We also propose the use of novel ion implantation and surface analysis techniques, e.g., atomic force microscopy and Z-contrast high resolution scanning transmission electron microscopy (STEM), in order to identify atomic-scale effects of radiation damage associated with single or small clusters of radionuclides sorbed onto mineral surfaces.

Expected Capabilities: Clay and zeolite colloids have recently been reported to be responsible for the migration of Pu for distances greater than one kilometer at the Nevada Test Site. We plan to use high resolution and analytical electron microscopy to characterize the different types of colloids present at the Nevada Test Site and at Hanford (with samples provided by collaborators at Sandia National Laboratories and Lawrence Livermore National Laboratory).

The results of this research will provide a fundamental understanding of retention or release of radionuclides from geologic materials (clays, zeolites and colloids) in radiation-fields.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Isotopic Tracers for Waste Fluid Tracking and Fluid-Soil Interactions: Hanford, Washington**

Tech #: 279	**Date Available:**	9/14/2003	Subsurface Science-Basic Understanding		
Ref ID: 73773	**Past Investment($K):**	230	**Future Investment($K):**	490	**EMSP**

Description: Isotopic measurements of groundwater at Hanford will be used to evaluate chemical and hydrologic controls on the transport and retention of radionuclides in the vadose zone and saturated zone. Isotopic ratios of the elements O, C, N, H, Sr, and U will be made on groundwater collected on the normal sampling schedule of the ongoing Groundwater Monitoring program, with some supplementary sampling. A comprehensive site wide database will be assembled that will represent the most complete isotopic characterization ever undertaken for an aquifer. More detailed sampling will concentrate on the 200 Areas, in particular the areas near and downstream from single shell tank farms. The results are expected to be a major augmentation to standard groundwater characterization, and will be sufficiently detailed to allow us to fully evaluate the potential of naturally occurring isotopic variations to understand groundwater and contaminant migrations. The Hanford site is ideal for the proposed study because of the number of regularly sampled groundwater wells, large isotopic contrasts between introduced waste fluids and natural groundwater, and the amount of other spatial and historical data that can be drawn upon.

Expected Capabilities: The results of this study will yield information that is critical for developing improved conceptual models for vadose zone and groundwater transport of radionuclides and other contaminants of concern. In particular, the isotopic tracing techniques allow us to track the movement of waste fluids, which is a significant augmentation to the use of contaminants to trace plumes, since the source term for the contaminants is more complicated than that for the waste fluids. Data from groundwater samples downstream from single shell tanks and other concentrated waste disposal sites, will allow us to evaluate the extent of chemical reactions between concentrated waste fluids and subsurface soils in the vadose zone. These reactions, which are hypothesized to occur but remain undocumented, may greatly modify the transport of radionuclides through the vadose zone beneath tanks.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Colloid Genesis/Transport and Flow Pathway Alterations Resulting From Interactions of Highly Reactive Waste Solutions and Sediments in the Vadose Zone**

Tech #: 280 | **Date Available:** 9/30/2003 | Subsurface Science-Basic Understanding

Ref ID: 73775 | **Past Investment($K):** 200 | **Future Investment($K):** 400 | **EMSP**

Description: The specific tasks are listed below.

□Determine the mechanisms, nature and quantity of particle generation, and its dependence on waste solution chemistry, sediment chemistry, mineralogy and surface chemistry, and temperature during waste fluid infiltration into Hanford sediments.
□Quantify the combinations of matric potential, flow rate, and solution chemistry (composition, ionic strength and pH), required to remobilize previously attached colloids.
□Quantify colloid transport and deposition (filtration) under vadose zone conditions through accounting for influences of matric potential, colloid properties, and solution chemistry.
□Quantifying and predict saturated and unsaturated hydraulic conductivity changes, and consequent changes in vadose zone flow paths.

To achieve these goals we will continue to test the Hanford Formation sediment used in our current study (containing a moderately wide range of grain-sizes), and select certain size fractions if necessary. The same simulated REDOX Tank Waste solution (TW) used in our current study, based on the composition of single shell tank SX-111, will be used. We may also alter the composition within the range of AgnewÆs (1995, 1996) estimation. The chemical composition of the infiltration soil solution will be based on the water extract composition of the Hanford sediment, with the sediment:water ratio of 1:05 to 1:10, to simulate deep vadose zone pore waters and near surface pore waters, respectively.

Expected Capabilities: The objectives of this proposed research are twofold. The first is to understand the mechanisms controlling reaction-induced colloid formation, remobilization, and transport in vadose environments, and to identify the nature and quantity of mobile colloids which actually contribute to enhancing contaminant transport under the Hanford Site conditions. The second objective is to identify the physical basis for predicting reaction-induced permeability changes and flow path alterations, and their impact on contaminant plume migration.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Plutonium Speciation, Solubilization, and Migration in Soils**

Tech #: 283	**Date Available:**	9/14/2003	Subsurface Science-Basic Understanding		
Ref ID: 73819	**Past Investment($K):**	270	**Future Investment($K):**	589	**EMSP**

Description: Key elements of this proposal are listed below:

□Determination of Pu distribution, oxidation state(s) and speciation in select soil samples from two contaminated sites-Hanford and INEEL. The speciation and additional characterization of Pu in these soils will aid in the remediation of these sites, assist in the understanding of Pu at other sites, and increase our understanding of actinide environmental chemistry. Once characterization is complete, Pu will be added to the samples to learn how additional Pu interacts with the specific matrix, i.e. is it reduced or oxidized and/or sorbed to particular phases.

□Study of chemical systems most important in Pu environmental behavior. This will provide critical thermodynamic data, as well as structural and chemical models, for environmental samples. Past literature on environmental sample characterization have reported the predominance of Pu(V) in sea and groundwaters and recent literature and waste isolation simulation studies have suggested the potential importance of Pu(VI) and colloidal Pu(IV). The speciation and redox chemistry of Pu(V) and Pu(VI) and the stability and migration of real and pseudo Pu(IV) colloids under environmentally relevant conditions will be investigated.

□Determination of the mechanism and thermodynamics of interactions between Pu and Mn phases and the potential release of Pu via redox cycling. Pu has been postulated and shown to be associated with redox active minerals, i.e. Fe and Mn (oxy)hydroxides and oxides. Pu association with particular minerals within samples from contaminated sites will be examined. This will provide information on the possible geochemical transformations and reactions with redox active minerals presently not understood.

Expected Capabilities: The DOE is currently conducting cleanup activities at its nuclear weapons development sites, many of which have accumulated plutonium in soils for 50 years. There is scientific uncertainty about the levels of risk to human health posed by this Pu accumulation and about whether or not Pu is migrating from Federal reserves onto public lands. To properly control Pu migration in soils, to better evaluate the public risk, and to design effective remediation strategies, a fundamental understanding of Pu speciation, transport, and release mechanisms is needed.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Modeling of Cation Binding in Hydrated 2:1 Clay Minerals**

Tech #: 225	**Date Available:**	9/14/2000	Subsurface Science-Modeling		
Ref ID: 54823	**Past Investment($K):**	359	**Future Investment($K):**	0	**EMSP**

Description:

Hydrated 2:1 clay minerals are high-surface area, layered silicates that play a unique role in determining the fate of ionic pollutants in the environment. These minerals, including smectites and vermiculites, make up a major component of many soils. Ionic pollutants, including radioactive metal ions, may displace interlayer cations from the clay and bind, sometimes irreversibly, to the fixed-charge sites on the clay layer sheets. This binding in turn has a significant impact on pollutant transport through soils and clay-based containment materials, and on groundwater and soil remediation strategies. The molecular mechanisms whereby cations bind to 2:1 clay minerals are, unfortunately, not fully understood. The compositional variability of clays, particularly the magnitude and location of isomorphic substitution sites, has a significant impact on their binding properties. In addition, the complicated balance between hydration forces and ion-clay interactions is often difficult to quantify.

We propose specifically to investigate the molecular origin of cation binding and mobility in hydrated clay minerals using simulation techniques. Computer simulations assist directly in building molecular intuition into chemical systems and provide a bridge between experiment and theory. Simulation models have been developed recently for investigations of clay hydration structures and basal spacings. To date, however, no calculations of cation binding thermodynamics have been reported.

Our simulations will be used to build a molecular-level understanding of cation binding, and to analyze theories for cation exchange in clays. Specific focus will be given to cesium (Cs+), strontium (Sr2+), and uranium(VI) (UO2 2+ and hydrolysis products) cations, in that order, and to smectite and vermiculite clays of varying composition. The ions are chosen because they are important ionic components of high-level waste (Cs+ and Sr2+) and spent fuel (UO2 +). Each of the ions are common radioactive contaminants present in groundwater and soils (uranium being the most common). Accurate simulation models for aqueous cesium and strontium solutions have been developed recently by us. A first-generation model for simulations of aqueous UO2 2+ solutions has also been developed recently, although accurate modeling of uranyl hydration and binding will require development of more sophisticated models that account for uranyl speciation as a function of pH. Variations in clay composition are a crucial feature of the research because the magnitude and location (tetrahedral -vs- octahedral layer) of the fixed-charge sites have a dramatic impact on cation binding to clays. One major goal of this research is the prediction of adsorption properties for individual clays directly from their molecular structure. This would directly impact radionuclide transport modeling in which binding constants serve as input parameters.

Existing theories to explain cation binding thermodynamics have been reviewed recently. Some theories are based upon an electrostatic description of ion hydration and binding, while others extend to include polarization effects in the context of hard and soft acid and base theory. Our simulations will provide a specific test of these theories by correlating exchange free energies with interlayer ion and water structures, degrees of hydration, clay basal spacing, and the nature of the clay-ion-water interactions.

Finally, our simulations will be used to investigate radionuclide transport through compacted clay materials, as might be found in nuclear waste repositories. The low permeability of compactedclays makes diffusion the principle mechanism for radionuclide transport. Simulation results will be compared with recent experimental measurements, some of which have raised questions regarding the specific mechanism of cation diffusion.

Expected Capabilities:

One key feature of geological repositories is the use of containment and backfill materials that can provide a sealing and sorbing buffer to radionuclide transport. Hydrated 2:1 clays, particularly smectites, are characterized by their tendency to swell when exposed to water. This leads to a 'self-sealing' behavior and slow transport of water and pollutants through compacted clays. The combination of swelling and adsorption properties makes smectites primary candidates for containment and backfill materials. Further studies of radionuclide transport through compacted clays is required, however, to validate the long-term effectiveness of these materials. Building a molecular understanding of cation binding and diffusion in these materials will assist in this process.

The general goal of our research is to develop molecular models for cation binding to clays through the use of computer simulations. These models will build our intuition into cation-clay binding phenomena while explicitly identifying the key elements in the interactions that account for observed binding behavior. This in turn will assist in predicting and understanding the distribution coefficients that are used to model pollutant transport through natural soils or containment materials. In addition, strategies for soil remediation will benefit from an improved fundamental understanding of the nature of the binding interactions.

Much of the research herein stretches the boundaries of existing computer modeling capabilities. The currently available clay-ion-water models have provided successful descriptions of ion hydration and swelling behavior in a variety of alkali-metal substituted clays. In contrast, little modeling work has been done on multivalent cation-clay systems. A proposal to validate our methods and models for calculations of monovalent cation exchange has been funded by the ACS Petroleum Research Fund. It involves the calculation of exchange free energies for the alkali-metal ion series in a clay designed to mimic Llano vermiculite (VTx-1). This particular clay system is well-characterized experimentally in terms of both exchange thermodynamics and hydrated structure. The experimental data on this system will provide a necessary validation of the methods and interaction models used in the simulations, laying an important foundation for the investigations here.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Chaotic-Dynamical Conceptual Model to Describe Fluid Flow and Contaminant Transport in a Fractured Vadose Zone**

Tech #: 240	**Date Available:**	9/1/1999	Subsurface Science-Modeling		
Ref ID: 55359	**Past Investment($K):**	2706	**Future Investment($K):**	0	**EMSP**

Description: Understanding subsurface flow and transport processes is critical for effective assessment, decision-making, and remediation activities for contaminated sites. However, for fluid flow and contaminant transport through fractured vadose zones, traditional hydrogeological approaches are often found to be inadequate.

We will first examine separately the geometric model of fractured rock and the flow dynamics model needed to describe chaotic behavior, then put the geometry and flow dynamics together to develop a chaotic-dynamical model of flow and transport in a fractured vadose zone.

We will conduct laboratory and field experiments designed to test the model. In the field experiments, we will measure the timevariation of water flux, moisture content, and hydraulic head at various locations, as well as the total inflow rate to the subsurface. Such variations reflect the changes in the geometry and physics of water flow that display chaotic behavior, which we will try to reconstruct using the data obtained.

Expected Capabilities: In this project, we will examine flow and transport through a fractured vadose zone as a deterministic chaotic dynamical process, and develop a model of it in these terms. We will use the model to predict the long-term bounds on fluid flow and transport behavior, known as the attractor of the system, and examine the limits of short-term predictability within these bounds. This approach is especially well-suited to the need for short-term predictions to support remediation decisions, and long-term bounding studies.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: The Dynamics of Vadose Zone Transport: A Field and Modeling Study Using the Vadose Zone Observatory

Tech #: 267	**Date Available:**	9/14/2002	Subsurface Science-Modeling		
Ref ID: 70149	**Past Investment($K):**	400	**Future Investment($K):**	200	**EMSP**

Description: A stated need of the DOE EM program is a better understanding of basic vadose zone fluid flow and contaminant transport processes for the purpose of making improved estimates of contaminant release rates and fluxes across the vadose zone to the water table at DOE sites such as the tank farms at Hanford. We propose to investigate details of the modes of contaminant transport with the aid of infiltration experiments designed to elucidate how vadose zone characteristics such as preferential pathways, heterogeneities, and relative permeabilities influence the transport of contamination in liquid, gas and colloidal phases to the water table. Beyond enhancing our basic understanding of vadose zone transports processes, this proposed effort would result in a vadose-zone-transport-characterization methodology that can be generalized to other DOE sites. To accomplish this, we will use the newly developed
Vadose Zone Observatory (VZO) at Lawrence Livermore National Laboratory (LLNL) to carry out a partially subsidized, highly cost-effective study of multiphase fluid flow and colloidal transport in a heterogeneous unsaturated zone bearing dynamic resemblance to one type of Hanford vadose regime.

Expected Capabilities: With the goal of providing a comprehensive picture of multiphase vadose zone flow and transport, LLNLÆs NUFT (Non-isothermal Unsaturated Flow and Transport) computer program will be used to develop diagnostic models that serve as a framework for interpreting the wide variety of observations obtained during an infiltration experiment. With support from a hydrogeologist at Hanford, modeling will also provide the basis for applying our enhanced understanding of contaminant transport at the VZO to addressing transport issues at Hanford. Finally, by carrying out some infiltration experiments jointly with other LLNL principal investigators and a geophysical instrumentation company, we will leverage our effort as well as collaborate with them in developing improved subsurface imaging interpretations and technologies based upon the ERT and electromagnetic induction methods.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Complex Electrical Resistivity for Monitoring DNAPL Contamination

Tech #: 256	**Date Available:**	9/14/2002	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 70012	**Past Investment($K):**	510	**Future Investment($K):**	0	**EMSP**

Description: To accomplish these goals, we will: (1) perform laboratory studies to identify complex resistivity signatures of the most important components of DNAPLÆs; (2) evaluate the signal and noise levels in the field; (3) identify distinguishing characteristics of complex resistivity contaminant signatures and develop algorithms to identify them; (4) perform parameter studies of complex resistivity signature changes among natural rocks, soils, fluid chemistry, and saturation levels; (5) evaluate the ability of standard electrical geophysics field equipment to measure these effects. If standard equipment is unsuitable, develop prototype frequency-sweeping portable equipment with modern phase lock-in electronics to give field measurements the noise immunity required to reliably discern the low-level signals; (6) develop a broad-band pulse method for rapid data acquisition and scoping measurements; and (7) develop measurement techniques and software for complex resistivity imaging from arrays of surface electrodes.

Expected Capabilities: We propose to develop new practical complex resistivity field measurement techniques for pollution characterization and monitoring. For this purpose we will document the detectability of clay-organic interactions with geophysical measurements in the laboratory, develop further understanding of the underlying physical and chemical mechanisms, and then apply these observations to develop field techniques to monitor the remediation of organic pollutants. This proposed work is driven by the following simple hypothesis: as organic compounds are removed (e.g., biodegraded or extracted through engineered remediation) the complex resistivity will change according to the new chemical make-up of the soil/groundwater system. Thus complex resistivity measurements can be used as an effective monitoring tool to indicate the progress of remediation activities.

A field implementation of the complex resistivity technique targeted at pollutant characterization would provide a quick and inexpensive means of monitoring the progress of the breakdown of the pollutants in-situ without intervention and without disturbing the process. This technique would be implemented, for example, through the emplacement of standard 2-D arrays of contacting electrodes combined with complex resistivity measurement equipment, techniques, and data analysis methods. These data would be used to create spatial images of the pollution location and concentration in the subsurface. Successive images through time would be subtracted to monitor the remediation efforts.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: High Frequency Electromagnetic Impedance Measurements for Characterization, Monitoring and Verification Efforts

Tech #: 281

Ref ID: 73776

Date Available:	9/14/2003	Surveillance and Monitoring-Data Collection/Samp/Anal		
Past Investment($K):	280	**Future Investment($K):**	590	**EMSP**

Description: The proposed research plan consists of three tasks: 1) continued development and completion of high-frequency field measurement techniques, 2) construction and delivery of a field-hardened prototype HFI system, and 3) data processing, analysis, and interpretation. The proof-of-concept for the HFI system has been demonstrated in the first phase of the research program (1997 through 2000). Construction of a mobile HFI field system can be accomplished using off-the-shelf instrumentation and commercially available components, but research will be continued to develop better high-frequency sensors using innovative designs. Development of an analysis package for processing and interpretation of high-frequency data is also an essential part of the proposed work,, Towards the end of the project, the prototype system will be capable of real-time I mapping of the electrical conductivity and permittivity using simultaneous inversion in one dimension. Feasibility for implementing higher-dimensional analysis package in field operation will be critically evaluated.

Expected Capabilities: We propose to continue development of high-frequency impedance (HFI) methodology utilizing a window in the electromagnetic (EM) spectrum from 1.0 MHz to 100 MHz. This window, located between GPR and low-frequency induction techniques, has not been used to non-invasively investigate the upper few meters of the ground for environmental applications. Modeling and physical parameter studies confirm that impedance measurements in this frequency band can yield high-resolution mapping of electrical conductivity as well as the permittivity of near surface formations. In principle the impedance method we propose is free of source coupling for plane waves, so that the ensuing data analysis tends to be much simpler.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Engineered Antibodies for Monitoring of Polynuclear Aromatic Hydrocarbons**

Tech #: 285

Ref ID: 54546

Date Available:	9/14/2000
Past Investment($K):	891
Future Investment($K):	0

Surveillance and Monitoring-Ecosystems

EMSP

Description: The objective of this multidisciplinary project is to use molecular biological techniques to derive a set of antibodies with useful affinities and selectivities for recovery and detection of polynuclear aromatic hydrocarbons (PAHs) in environmental and biological samples.

Our research approach is to recover the genes of useful antibodies, express them in bacteria, develop 3-dimensional structural models to visualize antibody-antigen interactions, and then derive improved variants by directed and combinatorial mutagenesis. A recombinant antibody's affinity, selectivity, and other physical, chemical and structural properties may be changed to make it a more suitable analytical tool. We recently cloned and expressed recombinant Fab fragments that competitively bind 3, 4, and 5-ring PAHs. We will develop models of the combining sites to guide the design of mutants with altered functions. We will also search for PAH-specific recombinant Fabs or single-chain Fv antibodies (ScFvs) by screening the latest generation of immensely diverse combinatorial Fab and ScFv phage display libraries on selected PAH haptens. This should yield antibodies with sufficiently distinct binding properties for pattern recognition, without the need for conventional immunization, animal use, and hybridoma development.

Expected Capabilities: The long-term goal is to develop immunodetection methods that will be useful in biomarker research and regulatory monitoring of PAHs.

Immunoaffinity and immunoassay methods are increasingly being used worldwide to detect and estimate amounts of man-made pollutants and toxic natural products. The use of monoclonal antibodies (MAbs) improved the performance and reliability of many of these methods. The present generation of hazardous substance immunoassays uses antiserum or a single MAb to recognize individual analytes or a group of similar analytes. Future assay formats such as sensor arrays will employ panels of antibodies to identify multiple analytes using cross-reactivity pattern recognition. We are using recombinant antibody methods that offer new ways to obtain antibodies with useful cross-reactivity patterns for PAHs and similar compounds.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Development of an In-Situ Microsensor for the Measurements of Chromium and Uranium in Groundwater at DOE Sites**

Tech #: 217	**Date Available:**	9/14/2000	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 54639	**Past Investment($K):**	690	**Future Investment($K):**	0	**EMSP**

Description: The goal of this program is to develop, optimize and deploy a silicon-based micromachined stripping analyzer for field monitoring trace levels of chromium and uranium. Such system will integrate the sample-handling steps and necessary chemical reactions (using a flow-injection operation) with the already proven adsorptive-stripping voltammetric operation on a small planar chip.

In order to fully exploit this opportunity, it will be necessary first to develop a fundamental understanding of the behavior of such scaled-down flow-injection stripping system. Considerations of proportionalities and similarity will thus be used for deriving theoretical expressions for the dependence of the response upon variables to be miniaturized. The new knowledge will serve as a useful guideline for the rational design of the system manifold, and through the optimization, characterization and field deployment of the micromachined analyzer.

Expected Capabilities: Besides the drastic reduction in the size of the analytical system, such miniaturization should lead to increased speed, minimal reagent consumption and disposal, higher sensitivity and improved precision, and would thus revolutionize the way by which toxic metals are being monitored. Overall, this research will create powerful and economical microsystems for in-situ monitoring of metal contaminants in DOE sites, and will shed useful insights into the micromachining and behavior of miniaturized flow analyzers, in general.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Construction of Bending Magnet Beamline at the APS for Environmental Studies**

Tech #: 224	**Date Available:**	9/14/1999	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 54800	**Past Investment($K):**	810	**Future Investment($K):**	0	**EMSP**

Description: To help satisfy the growing need for synchrotron radiation based environmental research, it is proposed to carry out the design and construction of a bending magnet (BM) beamline at the Advanced Photon Source (APS) by the Pacific Northwest Consortium-Collaborative Access Team (PNC-CAT). The line will be optimized for various forms of x-ray absorption spectroscopies (XAS). Environmental and cleanup issues are a major focus of the fundamental research to be performed on the BM beamline. The beamline will share the PNC-CAT experimental facilities to be fabricated for the neighboring Undulator A Insertion Device beamline to utilize the experimental techniques of x-ray absorption spectroscopy for both bulk and surface studies, with spatial and time resolution and elemental imaging, on toxic and radioactive samples.

The PNC-CAT was formed to develop a sector at the Advanced Photon Source (APS), a third-generation synchrotron radiation x-ray source under construction at Argonne National Laboratory. This source will be completed in 1996-1997, and its distinguishing feature will be the use of insertion devices such as undulators which increase source brightness by orders of magnitude over previous generation synchrotrons. The PNC-CAT will employ this source brilliance to develop a unique x-ray microbeam of unprecedented flux density with beam size and resolution down to ~0.1 micron, and tunable over the range 4-25 keV for a variety of research projects. Equipped with an x-ray microprobe, advanced fluorescence detectors, radioactive sample facilities, and surface scattering and XAFS equipment, the PNC-CAT beamlines provide unique facilities for basic research into environmental problems.

Expected Capabilities: Synchrotron radiation studies of materials at the molecular scale can make important contributions to the understanding of the basic science issues underlying environmental cleanup efforts. A recent DOE workshop report "Molecular Environmental Science: Speciation, Reactivity, and Mobility of Environmental Contaminants" (July 5-8, 1995) emphasizes the important role to be played by synchrotron techniques, especially in the hard x-ray range. This view is confirmed by the increasing numbers of environmental programs which are employing synchrotron techniques, and the report also concludes that the available beamtime for such experiments is likely to be saturated in the near future. It is equally important that the beamtime be accompanied by the appropriate support for environmental studies, such as the capabilities for handling radioactive samples. To address these issues the Pacific Northwest Consortium-Collaborative Access Team (PNC-CAT) is proposing to build the optics and beam transport of a bending magnet beamline to deliver x-rays to an experimental enclosure. The beamline will be located at sector 20 of the Advanced Photon Source (APS), and will share important environmental support facilities with an insertion device beamline already under construction.

For example, a number of ongoing Environmental Management (EM) problems will be addressed by the basic research planned for the beamlines. These include:

ò Improved waste processing and separation technologies.

ò Alternative waste forms capable of better handling of problematic species such as Ti or phosphates.

ò Verification of modeling for the transport of contaminants under geologic conditions.

ò Chemical speciation of tank wastes.

ò Atomic scale structure of active sites in metallo-enzymes proposed for bio-catalytic reduction of actinides, metal contaminants and chlorinated hydrocarbons.

ò Adsorption and catalytic interactions at mineral surfaces.

ò Radiation induced structural changes in waste forms.

ò Improved sensors for monitoring contaminants.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Surface Nuclear Magnetic Resonance Imaging of Water Content Distribution in the Subsurface**

Tech #: 227 | **Date Available:** 1/1/1999 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 54857 | **Past Investment($K):** 638 | **Future Investment($K):** 0 | **EMSP**

Description: The objective of this research is to advance the technology of nuclear magnetic resonance (NMR) for direct measurement of water content distributions in the subsurface. The proof-of-concept of this method has been demonstrated by Russian scientists at the Institute of Chemical Kinetics and Combustion at Novosibirsk, and more recently by the Israeli Institute of Petroleum Geology and Geophysics at Holon, Israel and at the company IRIS in France. We propose to make advances in three critical components of the technology: (1) Developing the 3-D inverse and forward models needed for processing and interpretation of field measurements; (2) Improvement of the design and prototype construction with commercially available electronic equipment; and (3) Testing of the computing algorithms and improved equipment at hydro geologically well characterized sites.

Expected Capabilities: Since the movement of many contaminants in the subsurface directly depends on the water content distribution, the proposed NMR research has the potential to greatly improve environmental risk assessments under a wide range of climatic conditions.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Seismic Surface-Wave Tomography of Waste Sites

Tech #: 237	**Date Available:**	4/14/2002	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 55218	**Past Investment($K):**	358	**Future Investment($K):**	0	**EMSP**

Description: Simple analytical solutions to the elastic wave equation do not exist for media with lateral heterogeneities and/or irregular geometries. Thus, for complex structures, interpretations have had to wait for practical numerical solutions and more advanced computational facilities. For these reasons, perhaps, the application of surface waves to shallow engineering problems has been slow.

Surface wave dispersion methods have been attempted in seismic reflection to constrain the corrections for time delays introduced by variations in near surface velocity structure. The difficulties and mixed results in defining these "static" corrections include variations in the ratio of P to S wave velocities, expressed as Poisson's ratio, and the significant differences in computational methods applied to surface wave dispersion and reflection data. In soils engineering, the spectral analysis of surface waves (SASW) has been developed for determining the pavement strength of road beds and liquefaction potential of soils. The SASW technique is based on surface measurements of phase velocity above a structure which is assumed to consist of flat layers.

The near surface can have a highly heterogeneous velocity structure. The velocity contrast between the soil layers and the unweathered rock can approach two orders of magnitude, when, in comparison, conventional reflection and refraction studies consider a 10 percent contrast very significant. Surface wave dispersion is sensitive to the depth and lateral variation in velocity contrasts of this high magnitude and thus are appropriate for examining the near surface. Typically, they are most sensitive to the shallowest layers and can complement refraction and reflection data which are more appropriate for deeper structures. In general, zones of soil and rock disturbances which have widths similar to or greater than their depths are ideal for detection by surface wave dispersion. These include trenches filled with debris, walled bunkers, and accumulations of liquid waste in depressed zones.

Expected Capabilities: In this work, we propose to extend the spectral analysis techniques to a tomographic inversion for group velocity and develop computer programs that will allow analysis at near real time in the field. More importantly, we propose research on techniques that will include lateral variation in structures.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Advanced High Resolution Seismic Imaging, Material Properties Estimation and Full Wavefield Inversion for the Shallow Subsurface**

Tech #: 244	**Date Available:**	9/14/2001	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 60115	**Past Investment($K):**	550	**Future Investment($K):**	0	**EMSP**

Description: We will apply methods to a number of high resolution profiles we have acquired and are proposing to acquire at sites with different near surface properties, including two active environmental remediation sites. The methods to be developed represent basic research in seismic imaging, and include advanced wavefield imaging using pre-critical to post-critical energy, velocity estimation and reflector focusing, and wavefield inversion techniques appropriate for imaging and estimating the material properties of the highly heterogeneous near surface environment. The research will build on the PIsÆ previous research developing seismic imaging and inversion methods tailored for petroleum exploration and crustal investigations. At all stages of the data processing we propose to exploit the entire wavefields commonly recorded (and often overlapping in time, space, frequency, and phase velocity) but customarily processed and interpreted independently in high resolution surveys.

Expected Capabilities: We propose to develop and test an integrated suite of imaging and inverse techniques appropriate to the range of wave propagation regimes customarily recorded in shallow seismic surveys. These techniques will address the extreme physical conditions found in the shallow environment, and thereby significantly advance the ability of shallow seismic investigations to produce high fidelity structural and material property maps of the subsurface. High resolution subsurface material properties maps are essential for characterizing the geometry of aquifers, aquicludes, and other fluid pathways, and therefore are essential for environmental remediation efforts.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Enhancements to & Characterization of the Very Early Time Electromagnetic (VETEM) Prototype Instrument & Applications to Shallow Subsurface Imaging at Sites in the DOE Complex**

Tech #: 245

Ref ID: 60162

Date Available:	5/20/2001	Surveillance and Monitoring-Instruments/Sensors/Devices	
Past Investment($K):	820	**Future Investment($K):**	0

EMSP

Description: We plan to accomplish the research objectives by a combination of hardware and software enhancements to the existing Very Early Time Electromagnetic (VETEM) prototype instrument, physical modeling experiments, numerical forward and inverse modeling, and field demonstrations. We will enhance the existing system with additional antennas, additional transmitter options, probably one or more gradiometer configurations, and a modified receiver. The instrument enhancements will be guided by numerical forward, inverse, and antenna modeling. We propose to develop fast forward and inverse modeling codes appropriate to the VETEM instrument in 1D and, if possible, 2D that will run on a PC for in-the-field interpretation, as well as more detailed post-processing models.

Expected Capabilities: The U.S. Geological Survey and the University of Illinois propose to improve the state-of-the-art of electromagnetic imaging of the shallow (0 to 5 m) subsurface in conductive media with potential applications to subsurface characterization, landfill stabilization, decontamination/decommissioning, and waste characterization at sites in the DOE complex.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Investigation of Techniques to Improve Continuous Air Monitors Under Conditions of High Dust Loading in Environmental Settings**

Tech #: 246

Ref ID: 60163

Date Available:	12/31/2001	Surveillance and Monitoring-Instruments/Sensors/Devices	
Past Investment($K):	310	**Future Investment($K):**	0

EMSP

Description: Degrading factors to be studied include ambient aerosol particulate deposits on CAM filters, and the interactions of radon progeny background, as well as plutonium or uranium, with such deposit structures. Making use of recently available time-lapse video microscopic technology, the formation of dendritic structures from aerosol loading will be studied on present LANL CAMs. In addition, New Mexico Tech has recently received from the University of Lund a research prototype pulsed ionization chamber with large surface area. The possibility of adapting such pulsed ionization chambers for innovative CAM use will be investigated. Their ability to monitor filters with areas five to ten times larger than in present CAMs might lead to a significant alleviation of the aerosol loading problem and improved sensitivity from increased air sampling flow rates. Findings from the project will be of significance for the design of CAM pre-separators, filter media and use, development of data analysis software, and other critical CAM design and operational issues.

Expected Capabilities: The investigation is an in-depth exploration of environmental influences that can cause degradation of the performance (sensitivity, alarm functionality, etc.) of Continuous Air Monitors (CAMÆs), such as the LANL/Canberra alpha-particle CAM, and a study of techniques to correct for this degradation. The outcome will be a more reliable, sensitive air monitoring instrument for environmental settings such as waste processing/disposal sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Novel Miniature Spectrometer for Remote Chemical Detection

Tech #: 247	**Date Available:**	9/14/2003	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 60231	**Past Investment($K):**	549	**Future Investment($K):**	0	**EMSP**

Description: The sensor design utilizes a small, solid block (< 1cm3) of ultra-high purity optical material that is fabricated into a regular, planar polygon with a convex facet to form a total-internal-reflection ring cavity. For light undergoing sustained circulation by total-internal-reflection inside the solid, the facets of the polygon act as extremely high-reflectivity (99.9999% in some cases) mirrors, resulting in a relatively long and accurately measurable lifetime for an injected light pulse. Evanescent waves, which are generated by total-internal-reflection, are absorbed by matter in the vicinity of the cavity where the evanescent wave decays exponentially in space. The absorption spectrum is extracted by measuring the mean lifetime of an injected light pulse as a function of pulse carrier frequency. Errors associated with light source fluctuations, which typically limit the sensitivity of conventional absorption methods, are eliminated by this single pulse measurement, as in the gas-phase technique known as cavity ring-down spectroscopy. By locating the light source and detection system at a distance (e.g., 0.1 to 10 Km) through the use of fiber-optics, this new technology will permit remote, high-sensitivity, broadband chemical sensing with a rugged, cost-effective, miniature spectrometer.

Preliminary studies indicate the feasibility and design considerations for this new class of devices. For the laboratory program the technical tasks include: 1) experiments that verify chemical sensitivity, 2) development of a fabrication strategy for ruggedly mounting the coupling prisms to the TIR-ring cavity, 3) design and fabrication of TIR-ring cavities that allow detection of chemical species in the near-and mid-infrared (IR) spectrum, 4) development of a fiber-optic interface to TIR-ring cavities, 5) characterization of the technology by using these devices to detect chemical species of importance to the EMSP mission, and 6) investigation of potential interferences, e.g., particulates, abrasives, inhomgeneities, temperature and density gradients.

Expected Capabilities: This research will develop an entirely new class of chemical sensing technology that will enable qualitative and quantitative remote, real-time diagnostics of chemical species in hazardous gas, liquid, and semi-solid phases through a completely novel implementation of evanescent wave spectroscopy.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Miniature Nuclear Magnetic Resonance Spectrometer for In-Situ and In-Process Analysis and Monitoring**

Tech #: 248

Ref ID: 60247

Date Available:	9/14/2001
Past Investment($K):	482
Future Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

EMSP

Description: The new instrument will be a highly miniaturized version an NMR spectrometer and its development will involve application of the most recent advances in the fields of micromachining and microfabrication, permanent magnet materials and design, and microelectronics and signal processing. The proposed miniature NMR spectrometer will be a hand-held unit weighing around 5-6 pounds and intended to perform measurements on liquid samples of micro- to nano-liter volumes. The resolution of the instrument is projected to be better than 0.1 ppm (part per million) with sensitivities approaching 10 to 100 ppm (1 millimolar to 10 millimolar) for proton containing molecules. While initial developments will focus on applications of proton NMR, further developments will be aimed at other nuclei, such as 19F, 31P and 13C. Applications of the miniature NMR system will include down hole monitoring of ground water pollutants and flow, real-time in-process monitoring of waste remediation activities, spatial composition analysis in chemical and waste storage tanks, in-field characterization of waste materials and many others.

Expected Capabilities: The objective of this research project is to develop a new analytical instrument based on the principle of nuclear magnetic resonance (NMR) for in-situ, in-field and in-process characterization and monitoring of various substances and chemical processes.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Ultrahigh Sensitivity Heavy Noble Gas Detectors for Long-Term Monitoring and Monitoring Air

Tech #: 249	**Date Available:**	9/30/2001	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 60474	**Past Investment($K):**	609	**Future Investment($K):**	0	**EMSP**

Description: A new technique for concentrating the heavy noble gases from air will be integrated with state-of-the-art radiation detector technology to provide sensitivities on the order of two orders of magnitude better than current technology. In addition, these detectors can be configured such that heavy noble gas concentration in air is monitored continuously and recorded in real-time and in situ. This real-time data acquisition coupled with the ability to measure the beta particles and gamma rays emitted by krypton and xenon in coincidence mode will result in an enhanced ability both to use spectral information to detect and identify the different noble gas isotopes and to discriminate against all other signals. Finally, such an integrated concentration and detection system has the potential to provide low-cost and low-complexity detectors which would be ideally suited for long-term monitoring and fieldable air monitors.

It is proposed that a broad range of potential detectors and measurement techniques be identified and evaluated for use in DOE Environmental Management applications. Furthermore, at least two of the most promising techniques for detecting the heavy noble gas emissions will be developed experimentally. First, the concentrated radioactive gases can be mixed directly with standard proportional detector filled gases such that a 100% detection efficiency is realized when the mixture is passed through a proportional detector. Second, the concentrated gases can be used in scintillator flow-cell geometry to achieve a similar detection efficiency. While both of these techniques provide the ability to distinguish alpha and beta particle interactions within the detector, a gamma-ray spectroscopy detector can be used in coincidence mode with both techniques to further enhance background discrimination and species identification. Consequently, coincidence mode operation will also be demonstrated experimentally using both the proportional and the flow-cell detectors. If additional detectors and techniques are identified as promising, similar experimental development will be pursued for those systems. Finally, the developed detection systems will be evaluated and one or more systems identified, constructed, and demonstrated. This final demonstration of the technology will be conducted initially in the laboratory environment to establish operating characteristics, and subsequently will be conducted at a DOE EM site. To complete this detector development, a three-year team effort is proposed.

Expected Capabilities: A Georgia Institute of Technology/Argonne National Laboratory team will develop and demonstrate novel ultrahigh sensitivity heavy noble gas (krypton, xenon, and radon) detectors for long-term monitoring of spent fuel and TRU waste, as well as for distinguishing background radon alpha particles from other alpha emissions in air monitors.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Development of Novel, Simple Multianalyte Sensors for Remote Environmental Analysis**

Tech #: 250 | **Date Available:** 9/14/2002 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 65001 | **Past Investment($K):** 650 | **Future Investment($K):** 0 | **EMSP**

Description: These sensing materials are based on the intelligent polymerized crystalline colloidal array technology we recently developed. This sensing motif utilized a mesoscopically periodic array of colloidal particles polymerized into an acrylamide hydrogel. This array Bragg diffracts light in the visible spectral region due to the periodic array of colloidal particles. This material also contains chelating agents for the analytes of interest. When an analyte binds, its charge is immobilized within the acrylamide hydrogel. The resulting Donnan potential causes an osmotic diffracted wavelength shifts and the color changes. The change in the wavelength diffracted reports on the identity and concentration of the target analyte.

Our successful development of these simple, inexpensive highly sensitive chemical sensing optrodes, which are easily coupled to simple optical instrumentation, could revolutionize environmental monitoring. In addition, we will develop highly rugged versions, which can be attached to core penetrometers and which can be used to determine analytes in buried core samples.

Expected Capabilities: We will develop simple, inexpensive new chemical sensing materials which can be used as visual color test strips to sensitively and selectively report on the concentration and identity of environmental pollutants such as cations of Pb, U, Pu, Sr, Hg, Cs, Co as well as other species. We will develop inexpensive chemical test strips which can be immersed in water to determine these analytes in the field. We will also develop arrays of these chemical sensing materials which will be attached to fiber optic bundles to be used as rugged multichannel optrodes to simultaneously monitor numerous analytes remotely in hostile environments.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Spectroelectrochemical Sensor for Technetium Applicable to the Vadose Zone**

Tech #: 255

Ref ID: 70010

Date Available:	9/14/2002	Surveillance and Monitoring-Instruments/Sensors/Devices	
Past Investment($K):	917	**Future Investment($K):**	133

EMSP

Description: The concept for this TcO4- sensor is innovative and represents a breakthrough in sensor technology. The sensor combines three modes of selectivity (electrochemistry, spectroscopy, and selective partitioning) into a single sensor to substantially improve selectivity. The sensor will consist of a basic spectroelectrochemical configuration that we have developed under our existing EMSP grant: a waveguide with an optically transparent electrode that is coated with a thin chemically selective film. Proof of concept of this spectroelectrochemical sensor has been demonstrated under our existing EMSP grant for the determination of ferrocyanide in Hanford tank waste. A prototype sensor has been developed and is currently undergoing testing using In-Farm and U-Plant Hanford simulated wastes. The key to adapting this generic sensor to detect TcO4- lies in the development of unique chemistry within the chemically selective film. This film will be developed so that TcO4- in the sample will partition into it by electrostatic attraction. Once TcO4- is loaded into the film, it is electrochemically converted into a Tc coordination compound that gives a strong optical signal associated with an electrochemical reduction/oxidation process. The magnitude of the absorbance change accompanying the electrochemical modulation of this coordination compound will quantitate the concentration of Tc within the film, which is proportional to the concentration of TcO4- in the sample.

Expected Capabilities: The general aim of our work funded by EMSP is the design and implementation of a new sensor technology that offers unprecedented levels of specificity needed for analysis of the complex chemical mixtures found at DOE sites nationwide. The specific goal of this proposal is the development of a sensor for technetium (Tc) that is applicable to characterizing and monitoring the Vadose Zone and associated subsurface water at the Hanford site. Subsurface contamination by Tc is of particular concern for two reasons: the extremely long lifetime of its most common isotope 99Tc (half-life = 2 x 105 years) and the fast migration in soils that its most common chemical form, pertechnetate (TcO4-) exhibits. The sensor will be capable of determining the concentration of Tc in various chemical forms including TcO4- and lower oxidation states of Tc that are complexed with organic ligands. The primary focus of this proposal is TcO4-, which is considered to be the dominant species in the Vadose Zone and subsurface water. The sensor will have the capability for on-site monitoring, either by immersion in subsurface water for continuous monitoring or for the immediate analysis of collected samples.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Material Property Estimation for Direct Detection of DNAPL Using Integrated Ground-Penetrating Radar Velocity, Imaging, and Attribute Analysis**

Tech #: 258

Ref ID: 70052

Date Available:	9/14/2002
Past Investment($K):	648
Future Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

EMSP

Description: In our approach, we focus on three aspects of reflected wave behavior - propagation velocity, frequency dependent attenuation, and amplitude variation with offset. Velocity analysis provides a direct estimate of dielectric permittivity, attenuation analysis is used to identify variation in conductivity, and AVO behavior is used to quantify the dielectric permittivity ratio at a reflecting boundary. Attribute analysis is integrated with sophisticated signal processing methodologies, not commonly applied in GPR investigation, which dramatically improve image resolution and spatial accuracy. We have completed much of the preliminary work to include theoretical development, numerical and physical modeling studies, and initial development of attenuation and AVO attribute extraction algorithms.

The next step in development of these methods is rigorous field testing under a variety of hydrogeologic conditions. To this end, the focus of our proposed work is field investigation. We have identified a number of sites suitable for controlled GPR investigation including the Hanford Site, WA, and four facilities designated as National Environmental Technology Test Sites (Dover AFB, DE; McClelland AFB, CA; Port Hueneme, CA; Wurtsmith AFB, CA). We propose to conduct a series of controlled and uncontrolled GPR experiments over known NAPL source areas at these sites. An integral part of data analysis will be continued development of attribute extraction algorithms. These algorithms will include methods for automated attribute extraction and material property estimation based on the physics of EM wave propagation.

Previous GPR NAPL detection studies have relied on minimal data processing and qualitative interpretation of subsurface profiles. Our approach combines sophisticated processing methodology with quantitative attribute analysis and material property estimation. The proposed research will lead to more efficient processing, reliable, accurate interpretations, and detection of subtle variations that are difficult or impossible to identify through qualitative interpretation alone. Implementation of these methodologies will be a significant advance in GPR research and in meeting DOEÆs need for reliable in-situ characterization of DNAPL contamination.

Expected Capabilities: We propose to test and develop a suite of methodologies for direct detection of pooled and residual DNAPLs from surface ground-penetrating radar (GPR) data. This is a new, quantitative approach to the analysis of GPR data in which we determine material properties remotely by quantifying signal characteristics such as propagation velocity and waveform attributes including amplitude, frequency content, and phase. With careful consideration of the physics governing electromagnetic (EM) wave propagation, these properties can be extracted from GPR data to characterize variations in electric properties. Many DNAPLs, including chlorinated solvents, have much lower dielectric permittivity and conductivity than water. A contrast in electric properties is induced when DNAPL displaces water in the sediment column resulting in an anomalous GPR attribute signature. The attribute signature can be exploited for remote DNAPL detection.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **The Use of Radar Methods to Determine Moisture Content in the Vadose Zone**

Tech #: 261

Ref ID: 70115

Date Available:	9/29/2002	Surveillance and Monitoring-Instruments/Sensors/Devices	
Past Investment($K):	372	**Future Investment($K):**	0

EMSP

Description: This proposal is a combination of laboratory, field and theoretical studies and addresses a number of issues all of which are related to the improved use of radar methods to determine moisture content in the vadose zone. The close link between imaged dielectric properties and moisture content strongly suggests that this is an ideal approach to obtaining estimates of in situ moisture content, a critical factor in addressing issues associated with contaminant transport in the vadose zone. The successful completion of this proposed research will allow for improved accuracy in extracting information about both the magnitude of moisture content and its spatial distribution in the vadose zone.

Expected Capabilities: The overall objective of our proposed research is to further develop the usefulness of radar methods (ground-based and borehole) as a means of characterizing moisture content in the vadose zone.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Radionuclide Sensors for Water Monitoring

Tech #: 270

Ref ID: 70179

Date Available:	9/14/2002
Past Investment($K):	625

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	200

EMSP

Description: We propose a research program directed toward developing novel sensor concepts and materials for sensitive and selective determination of beta- and alpha-emitting radionuclide contaminants in water. In order to meet the requirements for isotope specific detection at ultra-low regulatory levels the proposed sensors are based on radiometric detection. In order to address the fundamental challenge of short ranges of beta and alpha particles in water, our overall approach is based on localization of preconcentration/separation chemistries directly on or within the active area of a radioactivity detector, using automated microfluidics for sample manipulation and sensor regeneration or renewal. Radionuclides of primary interest for DOE needs are Sr-90, Tc-99, and actinides.

Expected Capabilities: The outcome of these investigations will be the knowledge necessary to choose appropriate chemistries for preconcentration of radionuclides with selectivity over other matrix components and interferences, new materials that combine chemical selectivity with scintillating properties, new materials that add chemical selectivity to solid state diode detectors, new preconcentrating column sensors, and improved instrumentation and signal processing for selective radionuclide sensors. New knowledge of the performance of sensing materials, sensor configurations, microfluidic techniques, and quantitative analytical approaches will provide the basis for designing effective probes and instrumentation for field analytical chemistry.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Automating Shallow Seismic Imaging

Tech #: 275	**Date Available:**	9/14/2003	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 73731	**Past Investment($K):**	396	**Future Investment($K):**	396	**EMSP**

Description: The research we are proposing as a continuation of our EMSP contribution is designed to develop ultrashallow seismic imaging into a cost-effective method that could be applicable to DOE facilities. The objective of the research proposed here is to develop and demonstrate the use of a cost-effective automated method of conducting shallow seismic surveys. We emphasize that this approach represents a significant departure from conventional seismic-survey field procedures. Our initial testing suggests that large numbers of geophones can be placed automatically by a mechanical device, which could make the application of shallow seismic reflection (SSR) considerably faster and cheaper.

Expected Capabilities: The imaging results obtained using the proposed automated seismic methods will be compared with results obtained using classical seismic techniques as well as GPR surveys, and, in the third year of the proposed research, demonstration surveys at one or more DOE facilities will be performed. The techniques proposed here are not limited to shallow seismic reflection methods but would also be capable of collecting data for seismic-refraction and possibly for surface-wave studies. Although the research we propose falls primarily into the field of seismology, some ground penetrating radar (GPR) data will be collected at a very small additional incremental cost for comparison and quality-control purposes.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Microsensors for In-Situ Chemical, Physical, & Radiological Characterization Mixed Waste**

Tech #: 282 | **Date Available:** 9/30/2003 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 73808 | **Past Investment($K):** 200 | **Future Investment($K):** 430 | **EMSP**

Description: A widespread need exists for portable, real-time, in-situ chemical, physical, and radiological sensors for the characterization and monitoring of mixed waste, groundwater, contaminated soil and process streams ranging from plume containment and remediation to determination of location, chemical composition, and level of DNAPLs. In the first phase of this EMSP program, we have successfully demonstrated sensitive microcantilever sensors for solution with unprecedented sensitivity. However, the molecular level mechanism responsible for sensor action still remains poorly understood and this limits our ability to rationally design more sensitive and selective sensors for a variety of target analytes especially when more than one analyte is present.

Expected Capabilities: The objective of this research phase is to gain a better understanding of the molecular-level mechanism of adsorption-induced stress on the microcantilever. The ability to manipulate and control these stresses will lead to the development of highly selective and extremely sensitive sensors for EM specific applications in liquid environment in presence of interferents. For example, it is possible to separate chemisorption and physisorption by simultaneous measurement of resonance parameters Based on this fact, we will develop and demonstrate corrosion resistant cantilevers with parts-per-trillion sensitivity for metal ions in solution such as Hg, CrO42-, Sr2+, and TcO4-. Selectivity will be achieved by orthogonal arraying of modified cantilevers. In addition, we will also develop microcantilever radiation sensors that can operate under solution.

We plan to bring the proposed prototype sensors to a stage where they will be field-tested in the third year. The advantage of the cantilever sensors is that once the basic platform is developed, it can be the basis for a plethora of inexpensive, miniature sensors.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Induced Polarization with Electromagnetic Coupling: 3D Spectral Imaging Theory and Field Tests**

Tech #: 284	**Date Available:**	9/14/2003	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 73836	**Past Investment($K):**	473	**Future Investment($K):**	312	**EMSP**

Description: The Earth Resources Laboratory (ERL) has made recent advances in applying the Induced Polarization (IP) method for detection and mapping of contaminant plumes. The ERL has developed a 3D complex resistivity and time-domain inversion codes, and performed modeling which shows that SIP requires a wide frequency range to be effective. Laboratory experiments have revealed that the greatest IP response to contaminants is at frequencies higher than 1KHz. However emc limits the effective frequency range to below 100 Hz, and present correction methods are inadequate. The project will address the em coupling problem by a fundamentally new approach; we will directly include em induction in the IP modeling inversion codes. In other words, we will treat the electromagnetic coupling (emc) as a data signal, with useful information about the conductivity structure, instead of as a useless noise signal.

A forward problem is to be developed which predicts both the IP and the em part of the data from a model. An appropriate inverse algorithm will be developed for 3D spectral IP field data. The new modeling will incorporate rather than eliminate em inductive coupling, extending the effective frequency range of SIP to the region of greatest interest beyond 1KHz. The new method will also increase the subsurface resolution of tomography as the em component of the data is fused with IP, where the em is sensitive to the conductivity structure. The project will also perform two field demonstrations of SIP and time domain IP at two sites.

Expected Capabilities: The original DOE project (DE-FG0296ER4714) was a broad foundational study of spectral IP (SIP) for site characterization. The project encompassed laboratory studies of microgeometry and chemistry effect on Induced Polarization (IP), an investigation of (emc) noise, and development of 3D modeling and inversion codes.The project showed that emc is the major limitation for field implementation of SIP and conventional correction methods are inadequate. The present project is more focused, with the aim of resolving the em coupling problem to enable inversion of spectral data in the desired higher frequencies above 1 KHz. The approach is to couple IP and em in the modeling and inversion based on MaxwellÆs questions. The objectives of the renewal project are

Extend the present 3D codes to include coupled IP-EM modeling & inversion
Demonstrate field applications of 3D SIP and time domain IP at two DOE sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Novel Optical Detection Schemes for In-Situ Mapping of Volatile Organochlorides in the Vadose Zone

Tech #: 257	**Date Available:**	9/14/2002	Surveillance and Monitoring-Subsurface Science		
Ref ID: 70050	**Past Investment($K):**	692	**Future Investment($K):**	133	**EMSP**

Description: Improved technologies are required by DOE for characterization and monitoring for site clean-up and waste processing applications. Especially needed are field deployable methods and devices for real-time monitoring to reduce dependency on laboratory analyses which are costly and time consuming. Improved sensing capabilities are needed for on-site analyses to provide real-time analytical capabilities for screening level and/or decision-quality data. Matrices of interest to the DOE are soils (or other solids), slurries, and aqueous and non-aqueous solutions.
In-situ methods have been demonstrated for identifying high concentrations of organic liquids (e.g., Raman spectroscopy) and low concentrations of a few types of organic molecules (e.g., UV fluorescence and DUVAS), as well as a few selected organic molecules (e.g., sensors) at low concentrations. However, currently there is no method for measuring low levels of organic vapors of the type that would be indicative of subsurface contamination in the vadose zone. The proposed research focuses specifically on a method, resonance-enhanced multi-photon
ionization - REMPI, for measuring organic solvents in a soil matrix by detecting organic vapors in the vicinity of a NAPL. We propose using this technique in combination with Raman spectroscopy thus allowing organic contaminants to be measured and identified over a very wide range of concentrations. Our proposed REMPI studies are different from current approaches in that we will use a visible laser for excitation rather than a UV laser, as is used by other groups, to reduce the cost and complexity of the instrumentation, and make the system more robust and reliable. Furthermore, visible wavelengths are more compatible with existing fiber-optic probes and will make it easier to make field measurements using long fiber cables.

Expected Capabilities: The proposed research focuses specifically on a method, resonance-enhanced multi-photon ionization - REMPI, for measuring organic solvents in a soil matrix by detecting organic vapors in the vicinity of a NAPL. We propose using this technique in combination with Raman spectroscopy thus allowing organic contaminants to be measured and identified over a very wide range of concentrations. Our proposed REMPI studies are different from current approaches in that we will use a visible laser for excitation rather than a UV laser, as is used by other groups, to reduce the cost and complexity of the instrumentation, and make the system more robust and reliable. Furthermore, visible wavelengths are more compatible with existing fiber-optic probes and will make it easier to make field measurements using long fiber cables.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Improved Risk Estimates for Carbon Tetrachloride**

Tech #: 228

Ref ID: 54940

Date Available:	9/1/1999	Toxicity-Benchmarking		
Past Investment($K):	1000	**Future Investment($K):**	0	**EMSP**

Description: Carbon tetrachloride (CCl4) has been used extensively within the Department of Energy (DOE) nuclear weapons facilities. Costs associated with cleanup of CCl4 at DOE facilities are driven by current cancer risk estimates which assume CCl4 is a genotoxic carcinogen. However, a growing body of evidence suggests that CCl4 is not genotoxic. In April 1996, the Environmental Protection Agency (EPA) published proposed new guidelines for cancer risk assessment. In the new guidelines, the agent's mode of action is considered, and conclusion of hazard may be made based on the route, duration, and magnitude of exposure. These proposed guidelines provide an opportunity to develop a broader, more scientifically based estimate of the human cancer risk associated with CCl4 exposure.

Expected Capabilities: The overall purpose of these studies is to improve the scientific basis for assessing the cancer risk associated with human exposure to CCl4. Specifically, we will determine the toxicokinetics of inhaled and ingested CCl4 in F344/Crl rats, B6C3F1 mice, and Syrian hamsters. We will also evaluate species differences in the in vivo metabolism of CCl4 by rats, mice, and hamsters and the in vitro metabolism of CCl4 by tissues and microsomes from these rodent species and man. Dose-response relationships will be evaluated in all these studies. This information will be used to improve the current physiologically based pharmacokinetic model for CCl4. We will also determine whether CC14, like chloroform, is a hepatocarcinogen only when exposure results in cell damage, cell killing, and regenerative cell proliferation. In combination, the results of these studies will provide the types of information needed to enable a refined cancer risk estimate for CC14 under the EPA's proposed new guidelines for cancer risk assessment. Application of a revised cancer risk estimate for CCl4 may result in less stringent levels for CCl4 cleanup at DOE facilities, thereby significantly reducing associated costs to the DOE.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Estimation of Potential Population Level Effects of Contaminants on Wildlife**

Tech #: 243	**Date Available:**	5/31/2001	Toxicity-Benchmarking		
Ref ID: 60037	**Past Investment($K):**	619	**Future Investment($K):**	0	**EMSP**

Description: Although risk managers for CERCLA sites are concerned with risks to wildlife populations. First, we will develop a database of dose-response functions for contaminants of concern to DOE EM. These toxicity data represent the foundation of all future work, because, to accurately interpret the significance of incremental increases in contaminant exposure, toxicity must be expressed as a function of exposure and not simple threshold values, as is the current practice. Because toxicity data are not available for all contaminants or wildlife species that may be considered in an ecological risk assessment, our second task will be to investigate and develop improved approaches for inter-species extrapolation of toxicity data. Our third task is to develop and parameterize matrix-based population models for selected wildlife species. When integrated with the contaminant exposure-response distributions, the population models will provide a tool to estimate population-level effects associated with differing levels of exposure and to compare these effects to other sources of mortality and environmental stresses. The issues of density dependence, spatial heterogeneity, stochasticity, and community-level interactions will be addressed for a subset of these species. The tasks outlined in this research are intended to reduce uncertainty associated with wildlife risk assessments. These uncertainties may have direct impacts on DOE EM satisfactorily fulfilling its mission in two ways. First, toxicity values may be too conservative. Risks to wildlife may therefore be overstated and remediation recommended when it is not needed. Second, some toxicity values may not be adequately protective and risks to wildlife may therefore be understated and remedial actions are not recommended when they are needed. Either of these alternatives results in inefficient use of limited EM funds and leaves DOE vulnerable to potential NRDA liability.

Expected Capabilities: The purpose of this project is to provide DOE with methods to assess risks to wildlife populations. We propose a series of tasks, culminating in the integration of contamination exposure-response function with species-specific population models for estimating the population-level effects associated with individual-level contaminant exposure.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Linking Molecular Event to Cellular Responses at Low Dose Exposures

Tech #: 253	**Date Available:**	9/14/2002	Toxicity-Benchmarking		
Ref ID: 69941	**Past Investment($K):**	466	**Future Investment($K):**	0	**EMSP**

Description: Defining low dose radiation cancer risks is limited by our ability to measure and directly correlate relevant cellular and molecular responses occurring at low dose and dose rate with tumor formation. This deficiency has led to conservative risk assessments based on low dose extrapolation models. A model system that would allow a direct correlation between observable cellular and molecular responses required for cellular transformation, and how these responses are modulated by low dose radiation, could provide a scientific basis to improve current risk assessments. We have now defined a cell transformation system in which there is a clear inhibitory effect of low dose (2 rad) gamma radiation on cell transformation. We also have the molecular foundation to permit investigation of thresholds in molecular and cellular responses.

The system of choice for these studies is the mouse JB6 model. This is the best characterized system for linking cell signaling responses to clonal expansion, providing established connections between cell signaling pathways and clonal growth, as well as a broad range of genetic tools for exploring low dose responses. The work proposed will:

1. Define the effect of low dose radiation on EGF- and TPA-mediated transformation in JB6 cells.

2. Determine whether molecular events (ERK activity, AP-1, p107) known to be critical for transformation exhibit thresholds that are perturbed by low-dose radiation.

3. Determine whether low dose radiation modulates the course of oxidative stress required for cellular transformation in response to tumor promoters.

4. Determine whether the low dose radiation response demonstrated in vitro are relevant to in vivo processes using a standard mouse skin initiation-promotion strategy. To date, the molecular processes defined as critical for JB6 transformation that have been examined in vivo have shown a direct extrapolation.

Expected Capabilities: The proposed work will obtain a quantitative understanding of the underlying mechanisms and their relationship to clonal expansion in order to establish the principles for low dose responses and to provide the data necessary for modeling effects below experimentally detectable limits. Establishing thresholds for critical regulatory steps in transformation-related signal transduction pathways would be an important advancement in the risk assessment of low dose radiation. These thresholds could be used to demonstrate non-linear relationships between low dose radiation and clonal expansion. If these data are appropriately incorporated into risk assessment models they could dramatically impact clean up levels and calculated risks to workers. This should ultimately reduce the cost of cleaning up contaminated DOE sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Mechanism Involved in Trichloroethylene-Induced Liver Cancer: Importance to Environmental Cleanup**

Tech #: 220

Ref ID: 54684

Date Available:	3/15/2001	Toxicity-Health Effects	
Past Investment($K):	1800	**Future Investment($K):**	0

EMSP

Description: The research proposed will provide direct input into that process from three interrelated projects: 1) To determine whether selection rather than mutation accounts for the TCE-induced shift in H-ras mutation spectra in tumors. Dose-response information necessary for risk-based standards must be developed in vivo. 2) To seek direct evidence for the selection mechanism in vitro. This will provide direct evidence of a non-genotoxic mechanism and is essential for selection of a non-linear extrapolation model for estimating risk at low exposures. The default model is linear, based on genotoxic mechanisms. 3) To determine the importance of the peroxisome proliferation activated receptor (PPAR) to TCE-induction of liver tumors as an alternative non-genotoxic mechanism. This would also justify use of a non-linear extrapolation model. If either mechanism is shown responsible for liver tumors induced by TCE, liver tumor induction will not be the most sensitive parameter for establishing clean-up standards. Thus, risk-based clean-up standards could increase by an order of magnitude.

Expected Capabilities: Clean-up costs for chlorinated solvents found on DOE sites are most frequently driven by trichloroethylene (TCE). More permissive standards for TCE would reduce DOE's complex-wide clean up costs by several billions of dollars. EPA is currently reviewing its risk assessment for TCE.

If either mechanism is shown responsible for liver tumors induced by TCE, liver tumor induction will not be the most sensitive parameter for establishing clean-up standards. Thus, risk-based clean-up standards could increase by an order of magnitude.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Human Genetic Marker for Resistance to Radiations and Chemicals**

Tech #: 234 | **Date Available:** 9/14/1999 | Toxicity-Health Effects

Ref ID: 55100 | **Past Investment($K):** 751 | **Future Investment($K):** 0 | **EMSP**

Description: Fission yeast Schizosaccharomyces pombe rad9 plays a key role in promoting radioresistance and chemoresistance since cells containing a mutation in this gene are highly sensitive to physical and chemical agents that damage DNA. Furthermore, rad9 mutant cells cannot delay cycling in early S phase or in G2 after incurring a block in DNA replication or DNA damage, respectively (i.e., they lack the early S phase and G2/M checkpoint controls). The inability to delay cycling appropriately is thought to be at least partially responsible for mutant sensitivity to DNA damaging agents, as the lack of checkpoints results in attempts to enter and complete mitosis in the presence of damaged DNA. The rad9 gene also regulates the activity of at least one DNA repair enzyme, SPDE, which is involved in repair of DNA damaged by UV light. Thus, rad9 mediates resistance to DNA damaging agents via cell cycle dependent, i.e., checkpoint control, and independent mechanisms.

In this proposal, we focus on the analysis of a recently isolated human structural homologue of S. pombe rad9, capable of partially rescuing the hyrdoxyurea sensitivity, radiosensitivity and related checkpoint control defects of rad9 null yeast. The following specific aims are designed to address the structure, function and regulation of this human RAD9, as well as to establish RAD9 as a tool to assess predisposition towards the development of deleterious health effects associated with exposure to radiations and chemicals. Given the significant role that fission yeast rad9 plays in radioresistance and chemoresistance, it is highly likely that RAD9 also has an important role in humans.

The following are the specific aims of the project, which focus on human RAD9:

Molecular characterization of human RAD9

a. Isolation and structure of the genomic version of human RAD9
b. In vitro mutagenesis to assess structure/function relationships
c. Expression in cells and tissues to assess regulation

Determining the role of human RAD9 in radio/chemoresponsiveness and cancer

a. Creation and characterization of human RAD9 mutant cells
b. The status of RAD9 in cervical cancer cells and other types of cancers and genetic disorders

Expected Capabilities: The overall objective of this research is to characterize the human RAD9 gene at molecular and cellular levels, and use the information and materials gained to develop a predictive assay for assessing risks posed to individuals involved in toxic waste clean-up.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Bioavailability of Organic Solvents in Soils: Input into Biologically Based Dose-Response Models for Human Risk Assessments**

Tech #: 241

Ref ID: 59828

Date Available:	9/14/2000	Toxicity-Health Effects	
Past Investment($K):	1104	**Future Investment($K):**	0

EMSP

Description: Remediation clean-up costs for soil contaminants on DOE sites vary dramatically with the level to which soil must be decontaminated. Although more is known about the uptake of neat chemicals, particularly solvents, through the skin, comparatively little is understood about the dermal bioavailability of solvents in soil, dust, sludge, sediment, etc.

Expected Capabilities: Fundamental research on the kinetics and bioavailability of solvent-laden soils will have an immediate impact on human health risk assessment by replacing conservative, default assumptions that assume contaminants in soil are well absorbed through human skin, reduce uncertainties in exposure/dose model paradigms, and in turn, serve to positively influence regulatory cleanup action levels. Depending on the contaminant and soil type, one or more orders of magnitude may be gained in acceptable risk levels at DOE sites.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Low-Dose Risk, Decisions, and Risk Communication

Tech #: 251	**Date Available:**	9/14/2002	Toxicity-Health Effects		
Ref ID: 69904	**Past Investment($K):**	810	**Future Investment($K):**	0	**EMSP**

Description: We begin with an overview of the problems facing risk communication and the existing capabilities. Risk controversies are viewed as based upon individual and group perceptions, judgments, and decisions. These social psychological conditions are modified or amplified by the societal context, in particular the social amplification of risk. The grant application suggests several areas where experimental research can and should be pursued to better understand these conditions.

Then we reference the context of social, cultural, economic and political factors. We note key places where additional research is called for and recommend case studies of communities where radiation exposure has been a controversial issue. In these studies, we would examine the nature of the controversies and the performance of the public decision processes.

Expected Capabilities: This grant application seeks funding for a program of basic research in the areas of risk perception and decision making as applied to the role of communication of biological research results on low-dose radiation exposure. Widespread adverse views about radiation exposure makes communicating with citizens, groups, and organizations difficult. While the problems are well-defined they are only partly understood and risk communication needs considerable development to aid in addressing public concerns. This communication must also be conducted in a societal context and through public decision processes that imposes constraints and difficulties.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: Sensitivity to Radiation-Induced Cancer in Hemochromatosis

Tech #: 252	**Date Available:**	9/14/2001	Toxicity-Health Effects		
Ref ID: 69939	**Past Investment($K):**	414	**Future Investment($K):**	0	**EMSP**

Description: Determination of dose-response relationships for radiation-induced cancer in segments of the population with high susceptibility is critical for understanding the risks of low dose and low dose rates to humans. Clean-up levels for radionuclides will depend upon the fraction of the population represented by these people and the lower bounds on their sensitivity to radiation. Most research on susceptibility to radiation has focused on variations in DNA repair genes. However, important segments of the population with conditions that provide a differential growth advantage for mutated cells have not been examined. We propose to pursue this question experimentally with mice having the same mutation as that found in the human disease, HFE knockout mice (Zhou et al., 1998). It is postulated that the major impact of HH will produce a "promotional" environment for radiation-induced cancer. In part this may be attributable to an increased likelihood of developing non-insulin-dependent diabetes mellitus (NIDDM). Development of NIDDM can be influenced by iron overload, but appears to be also found in heterozygotes where iron load is not an obvious factor (Nelson et al., 1995). If the HFE-knockouts are found to have higher sensitivity to radiation than their wild-type counterparts, steep dose response curves are anticipated that can serve to more clearly identify non-linearity or thresholds in the dose-response curve for low LET radiation. A pilot study using HFE-knockout homozygotes and heterozygotes has been designed to: 1) determine whether the knock-out mice have greater sensitivity to radiation-induced cancer of the colon, liver, and breast, 2) establish the dependence of this sensitivity on accumulation of iron, 3) determine the extent to which cell replication and apoptosis occur in these target tissues with varying iron load, and 4) correlate the increases in sensitivity with changes in insulin-related signaling in tumors and normal tissue from each target organ.

Expected Capabilities: The long-term objective of this project is to indicate whether people with hereditary hemochromatosis (HH) would display an increased susceptibility to cancer induced by low LET radiation.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

Techn. Name: **Low-Dose Studies with Focused X-rays in Cell and Tissue Models: Mechanisms of Bystander and Genomic Instability Responses**

Tech #: 254	**Date Available:**	8/31/2002	Toxicity-Health Effects		
Ref ID: 69980	**Past Investment($K):**	1169	**Future Investment($K):**	0	**EMSP**

Description: For low-LET radiations, the concept of DNA damage leading to mutation and cell death has been widely accepted, particularly at high doses (>1 Gy). However, this view has been brought into question with accumulating evidence that a number of transmitted effects play significant roles in radiation responses. The aim of the proposed study is to determine the roles of inter- and intra-cellular signaling in responses relevant to cancer induction by low-LET radiations. It builds on our work on genomic instability (Manti, et al., 1997; Belyakov et al., 1999) and bystander effects (Prise et al., 1998; Belyakov et al., in preparation) but exploits the capability of our focused low-energy X-ray microprobe (Schettino et al., 1997) to discriminate sub-cellular targets and pathways. This unique system provides the ability to target regions of one or more cells selected within a population using a ~0.5 ╡ m diameter beam of low-energy X-rays and revisit the irradiated and unirradiated cells and their progeny in time-lapse fashion to score effects on a cell-by-cell basis. The revisiting method has proved highly sensitive to score events accurately at low doses.

Expected Capabilities: We propose studies based on our experience of signaling responses induced both oxidatively and by radiation, seeking mechanistic relationships between them that may contribute to the development of improved models of human radiation risk. Using our novel low-energy X-ray microprobe and cytometry facility, the emphasis will be on studying the low doses and isolated electron track type of exposure generally occurring at the cellular level in people exposed to protection level doses and dose rates of low-LET radiation.

Sources: EMSP Database

Notes/ Other Info: All development is basic research. Available date indicates the last date of funding for that phase of the research.

EM-50 Category: ESP

Techn. Name: Water Soluble Chelating Polymers for Pu, Am Removal

Tech #: 211 | **Date Available:** 12/31/1996 | Surveillance and Monitoring-Engineered Units

Ref ID: 35 | **Past Investment($K):** 1505 | **Future Investment($K):** 0 | **ESP**

Description: Water soluble chelating polymers focuses on the development of a polymer filtration process for the removal and concentration of valuable metal ions from process and other wastewater. Specifically, the objective is to design water-soluble chelating polymers which can be bound selectively and allow for the concentration of dilute solutions of the radionuclides plutonium and americium. Some potential commercial applications of the technology developed include electroplating rinse waters, nuclear power plant cooling water, and producing textiles, paint, and dyes.

Expected Capabilities: Provides a method to remove plutonium from waste streams to below current limits. The polymer can be recycled and reused.

Sources: TMS

Notes/ Other Info: This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of hazardous waste-contaminated water.

Techn. Name: Inorganic Microsphere Sorbents

Tech #: 98 | **Date Available:** 9/30/2002 | Surveillance and Monitoring-Engineered Units

Ref ID: 38 | **Past Investment($K):** 969 | **Future Investment($K):** 0 | **ESP**

Description: Granular forms or microspheres of inorganic ion exchangers will be developed, tested and evaluated to remove radionuclides and heavy metals from liquid waste streams. In the lab, the microspheres have been demonstrated to be highly effective as sorbents for radionuclides. In this project, the most promising Inorganic microsphere sorbents will be tested for continuous processing of contaminated liquid waste streams contaminated with radionuclides and heavy metals.

Expected Capabilities:

Sources: TMS
TSS [Title]: Development and Testing of Inorganic Sorbents for Radionuclide and Heavy Metal Separations

Notes/ Other Info: This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of radionuclide-contaminated water.

Techn. Name: Electrochemical Treatment of Alkaline Nuclear Wastes

Tech #: 99 | **Date Available:** | Surveillance and Monitoring-Engineered Units

Ref ID: 39 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **ESP**

Description: Electrochemical treatment can assist in the management of many DOE aqueous wastes complicated by nitrates, nitrites, and organics. Electrochemical treatment 1) converts these species into harmless ammonia, nitrogen, carbon dioxide and water; 2) provides instantaneous control over reactions; 3) operates at safe, ambient conditions; 4) requires no added chemicals; and 5) can produce useful byproducts.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Awaiting decision for deployment. No date for completion was given. This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of hazardous waste-contaminated water.

Techn. Name: Membrane-Supported Particle-Bound Ligands for Cesium Removal

Tech #: 100 | **Date Available:** | Surveillance and Monitoring-Engineered Units

Ref ID: 179 | **Past Investment($K):** 2516 | **Future Investment($K):** 0 | **ESP**

Description: Flow-through membranes have been successfully used to remove contaminants from liquid waste streams. This project focuses on the development of inorganic ion exchangers which can be attached to the membranes to facilitate the selective removal of radionuclides from groundwater, reactor basin and other aqueous waste streams. The capacity, selectivity, and stability of the membrane system are evaluated.

Expected Capabilities: This technology removes contaminants of concern from various waste streams without needing much processing space.

Sources: TMS
TSS [Title]: Membrane-Supported Particle-Bound Ligands for Cesium Removal

Notes/ Other Info: Awaiting decision for deployment. No date for completion was given. This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of hazardous waste-contaminated water.

Techn. Name: Fission Products Separations Testing

Tech #: 101 | **Date Available:** 9/30/2000 | Surveillance and Monitoring-Engineered Units

Ref ID: 205 | **Past Investment($K):** 1147 | **Future Investment($K):** 0 | **ESP**

Description: A number of sorbents, ion exchangers, and advanced extractants are being developed to remove fission products [i.e., strontium (Sr) and Cesium (Cs)] from highly alkaline waste. Some of these sorbents may hold promise for treatment of contaminated ground water and process water. DOE, private industry and universities have developed new sorbent materials and processes that will be tested under various treatment conditions for ground water and process water decontamination. The goal is to evaluate the new sorbent and ion exchange materials, and/or other processes for liquid water decontamination that will be more selective for the removal of 90Sr and 137Cs than standard treatment methods. The more selective sorbent materials will be pilot field tested for cost comparison with the sorbents presently being used.

Expected Capabilities:

Sources: TMS
TSS [Title]: Fission Products Separation Testing: Use of Sorbent Materials for Treatment of Radionuclides in Waste Water and Groundwater

Notes/ Other Info: This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of hazardous waste-contaminated water.

Techn. Name: **Bi-functional Resin for Removal of Contaminants from Groundwater**

Tech #: 102

Ref ID: 255

Date Available:		Surveillance and Monitoring-Engineered Units	
Past Investment($K):	1141	**Future Investment($K):**	0

ESP

Description: The purpose of this project is to develop an anion exchange resin that will selectively remove the radionuclide technetium, in the form of the pertechnetate anion (TcO_4^-), from groundwater, leaving behind other interfering anions. A resin bed of this material will be used either as part of a coupled treatment-recirculation system for the in situ remediation of groundwater contaminated with technetium, or in a once-through treatment scheme. The pertechnetate anion is strongly adsorbed on commercially available strong base ion exchange resins, but in view of the low (nanomolar) concentra-tion of technetium involved, enhanced selectivity for the pertechnetate anion over other anions commonly found in groundwater such as chloride, sulfate, and nitrate will be needed.

Expected Capabilities: Provides a sorbent that is more selective for removing technetium than currently available sorbents.

Sources: TMS
TSS [Title]: Selective In Situ Sorption of Technetium From Groundwater

Notes/ Other Info: No date for completion was given. This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of hazardous waste-contaminated water.

Techn. Name: **Self Assembled Monolayers on Mesoporous Supports (SAMMs) for Separations Activities**

Tech #: 212 | **Date Available:** 9/30/2002 | Surveillance and Monitoring-Engineered Units

Ref ID: 1447 | **Past Investment($K):** 962 | **Future Investment($K):** 0 | **ESP**

Description: Self-Assembled Mercaptan on Mesoporous Supports (SAMMS) are developed for the removal and/or stabilization of heavy metals from dilute liquid wastestreams. The technology combines two areas of materials science: an inorganic high surface area support base and a self-assembled multilayer of organic materials, which bond to the support base. In exposing SAMMS to liquid wastes, SAMMS binds to hazardous metals, radionuclides, and organic materials to the support base. SAMMS materials can be used as cartridges for portable water treatment systems and as filtration membranes and separation columns for large municipal and industrial water recycle and treatment. Since SAMMS uses no chemicals or washing solutions, no regeneration of solutions are involved and no secondary wastes are generated.

Expected Capabilities: Provides a sorbent to remove mercury from various waste streams. No technology currently exists to remove both tritium and mercury from DOE waste oils.

Sources: TMS

Notes/ Other Info: This technology does not appear to be planned for LTS, but it may be applicable to pump and treatment of hazardous waste-contaminated water.

EM-50 Category: INDP

Techn. Name: Subsurface Barrier Containment System

Tech #: 32 | **Date Available:** 9/17/1999 | Physical Barriers-Subsurface Science

Ref ID: 2964 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **INDP**

Description: his technology deals with the feasibility of containing buried waste or subsurface contamination by using an innovative barrier installation process. The barrier installation process or system shall effectively and efficiently construct a continuous barrier without intrusion or disturbance to the waste requiring containment, and operate with a minimal perimeter so as not to disturb adjacent waste areas. The installed, containment barrier will be a continuous structure without discontinuities, that is constructed of durable, impermeable material, and serves to hydraulically isolate the waste site. Both the barrier installation process and the constructed barrier must meet required technology performance requirements, and must also meet any DOE site-specific and regulatory requirements that exist as a result of this demonstration. The technology must be at an advanced engineering development stage. Design and development of the installation process will be completed and then demonstrated at a buried waste site at one or more DOE sites

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -4

Techn. Name: Surface Altered Zeolytes as a Permeable Barrier

Tech #: 30	**Date Available:**	9/6/1996	Physical Barriers-Waste Forms		
Ref ID: 304	**Past Investment($K):**	2214	**Future Investment($K):**	0	**INDP**

Description: Contamination of shallow groundwater by organic and inorganic pollutants is common at many Department of Energy (DOE) and industrial facilities. Often it isn´t the level of contamination, but the volume of groundwater contaminated, which dictates the ultimate cost of groundwater cleanup. Any technology which can retard the migration of pollutants while remediation solutions are designed and implemented will be valuable. Impermeable slurry walls (composed, for example, of bentonite mixtures) attempt to prevent the bulk movement of contaminated groundwater. Due to the resulting hydraulic gradients, such underground dams often fail due to groundwater movement over, under, or around the barrier. Solution: Development, pilot-scale demonstration, and field installation of a permeable barrier of altered zeolite which is selective for the major classes of groundwater contaminants: soluble organics such as benzene and trichloroethylene, inorganic cations such as lead and cadmium, and inorganic anions such as chromate and arsenate. Such a barrier would retain contaminants while allowing the groundwater to pass through.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Advanced Worker Protection System

Tech #: 21	**Date Available:**	3/30/2000	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 75	**Past Investment($K):**	3456	**Future Investment($K):**	0	**INDP**

Description: The Advanced Worker Protection System (AWPS) is a liquid-air-based, self-contained breathing and cooling system with a duration of 2 hr. AWPS employs a patented system developed by Oceaneering Space Systems (OSS), which was supported by the Department of Energy's (DOE's) Morgantown Energy Technology Center through a cost sharing research and development contract. The heart of the system is the life-support backpack that uses liquid air to provide cooling as well as breathing gas to the worker. The backpack is combined with advanced protective garments, an advanced liquid cooling garment (LCG), a respirator, and communications and support equipment.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Intelligent Inspection and Survey Robot

Tech #: 24	**Date Available:**	1/1/1996	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 272	**Past Investment($K):**	1905	**Future Investment($K):**	0	**INDP**

Description: Mobile robots and schemes for autonomous navigation have been under development at various universities and National Laboratories. An autonomous inspection system such as ARIES, however, has not been demonstrated. The mobile robot system is designed with enhanced intelligence and navigation capabilities to conduct routine inspection of stored waste drums. ARIES will maneuver in aisles which are 36" or greater in width. The system will be capable of deploying on an assigned inspection mission, collecting of required survey and inspection information, generating and maintaining mission data records, and reporting the completion of the mission. The system consists of the following major subsystems: a newly designed narrow-aisle vehicle base and application turret; an onboard
ultrasonic system and lidarc system for navigation and collision avoidance; radio communications systems; an autocharging station with docking instrumentation and referencing capability; work packages for the manipulations of cameras and other instruments; and onboard and offboard computing systems for mission planning, management, and reporting. A vision work package is comprised of a camera, illumination systems, and a deployment system along with pattern recognition software that can identify "suspect" drums. This visual inspection module will be used during autonomous inspection missions that may be deployed during work shifts when personnel and other equipment would not be in the warehouse. The acquired data can be sent via the charging station, or other autodocking stations designated for that purpose, to offboard computers. A database containing information from the inspection and survey missions will be available for the generations of routine reports and special reports that may be required by DOE and EPA. All such data will be added to the drum database that is maintained during the autonomous survey. Thus, inventory control would be completely automated consequently minimizing manpower requirements.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -6

Techn. Name: Road Transportable Analytical Laboratory (RTAL)

Tech #: 29

Ref ID: 292

Date Available:	9/30/1996
Past Investment($K):	0

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K):	0

INDP

Description: The Road Transportable Analytical Laboratory (RTAL) was developed to meet the unique needs of the Department of Energy (DOE) for rapid, on-site, low cost, and accurate analysis of environmental samples (soil, groundwater, and surface waters) for all samples of concern, including radionuclides. The RTAL design makes maximal use of laboratory automation and robotics technologies to dramatically shorten turnaround time and lower analytical costs while maintaining the highest levels of quality assurance and control. The RTAL is designed to be able to fully analyze samples within 16 hours, providing critical analytical data several days, weeks, or months faster than is currently achievable. Cost analyses show potential savings from analytical costs alone of $12 million per year for each RTAL system deployed compared to current central laboratory costs. Benefits: Analysis of a full range of radiological, chemical and biological contaminants and constituents at highest levels of quality assurance Dramatic reduction in analytical costs and turnaround time Robotics incorporated to maximize efficiency Full protection for operating personnel and sensitive analytical equipment against the radiological and environmental hazards encountered at DOE sites System easily modified to site needs since individual
modules are designed to be fully road transportable, totally independent, and highly flexible Technology: The RTAL system consists of a set of individual laboratory modules deployable independently or as an interconnected group to meet individual site needs. Each module provides full protection for operations and sensitive analytical equipment against radioactive particulates and conventional environmental contaminants.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Surface Acoustic Wave/Gas Chromatography System for Trace Vapor Analysis

Tech #: 25

Ref ID: 282

Date Available: 9/21/1996

Past Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

INDP

Description: Field personnel are currently hampered in identifying hazardous materials and for monitoring toxic waste site cleanups. Current methods are to setup mobile laboratories with highly skilled technicians and chemists at the site or to obtain samples and transport them to a regional laboratory for identification and analysis. Either option is time consuming and expensive. Solution: Electronic Sensor Technology (EST), a Division of Amerasia Technology, Inc., has developed a portable, highly sensitive, rugged vapor detector system (Model 4100 Trace Vapor Analyzer) which provides for low-cost, accurate vapor detection and analysis. Its purpose is to provide a low cost instrument for identifying hazardous materials and for monitoring Department of Energy (DOE) waste site cleanups throughout the United States.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Long-Term, Post-Closure Radiation Monitor

Tech #: 27

Ref ID: 288

Date Available:	9/30/1999
Past Investment($K):	885
Future Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

INDP

Description: Monitoring of radionuclides at Department of Energy (DOE) waste sites is necessary to determine if there may be potential impacts to human health or the environment based on the characteristics and movement of the radionuclides present. Monitoring will likely continue long after site cleanup has been completed. This post-closure monitoring of radionuclides will require that large numbers of sensors be installed below ground surface and monitored for long time periods (30 years is typical). Existing monitoring systems are too complex and expensive to maintain in place for long time periods. Solution: Configure commercially available components into a reliable, low-cost, multi-point system for long-term, post-closure monitoring. This system is based on gamma detection and is planned to be capable of monitoring to depths of more than fifty meters below ground level without having to drill wells. Scintillator probes are installed at each measurement location and are multiplexed to a single above-ground electronics unit. The individual scintillators will be located inside hollow tubes installed vertically or horizontally in the vadose zone at a waste site, using cone penetrometer technology. Benefits: Provide in situ long-term and real-time measurement techniques for monitoring contaminant leakage. Each scintillator is relatively small and can be produced at low cost. Scintillator is passive and operates at ambient temperatures; downhole components have demonstrated reliability. Long lived with components readily accessible for any required maintenance without soil disturbance. All system components are commercial or near-commercial. Technology: This radiation monitoring system is based on gamma detection and is designed to be capable of monitoring large numbers of permanently installed probes. Major components of the system incorporate commercially available scintillation, detectors, and signal processing electronics. Scintillation probes are installed to depths necessary to adequately monitor a given site. These probes may be installed in existing boreholes or wells, through the use of cone penetrometer technology, or if necessary, by using standard drilling methods. These probes will be connected to above-ground electronic components and multiplexed to a single data concentrator using RF links. The use of RF multiplexing with the specific electronic components identified for this system allows monitoring of a large number of probes. The above-ground location of most of the electronic components and the absence of below-ground components that require maintenance will minimize long-term costs.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -6

Techn. Name: Portable Analyzer for Chlorinated Compounds

Tech #: 31

Ref ID: 313

Date Available: 10/10/1996

Past Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

INDP

Description: A fully portable, hand-held, solid-state-sensor-based monitoring system that measures low concentrations of chlorinated organic compounds has been developed and is available for field demonstration. The system is capable of detecting chlorinated hydrocarbons in the range of 0.2-25 ppm and up to 500 ppm with an internal dilution feature that is incorporated into the instrument. The portable analyzer can be used to analyze samples from start-up in less than 15 minutes or in a continuous monitoring mode in 10 minutes or less. The system is designed for field use by technicians wearing protective clothing and for easy maintenance. The instrument can be operated from an AC line or from an internal battery.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Tomographic Site Characterization Using CPT, ERT and GPR

Tech #: 26

Ref ID: 284

Date Available:	9/30/1998
Past Investment($K):	722

Surveillance and Monitoring-Subsurface Science

Future Investment($K):	0

INDP

Description: ARA is developing a geophysical tomographic system that incorporates results from Electrical Resistivity Tomography (ERT) measurements and Ground Penetrating Radar (GPR) Tomography measurements. Both methods are useful for imaging subsurface structures and processes, however, GPR is more effective in sandy material and ERT is more effective in clayey material. CPT or drilling is used to deploy the electrodes in the subsurface The combination of these technologies into one system provides a cost-effective alternative for identification of soil type, clay lenses, and possibly DNAPL plumes. The system can also be used to quantify porosity, density, and soil moisture content. The technique is applicable for monitoring a variety of remediation systems. It is also applicable for characterization of burial trenches and pits, including boundaries and contents. It has been used to detect leaks under tanks at Hanford, WA. This technique was implemented in September 1998 to monitor the zone of capture of the GeoSiphon remediation site at TNX.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

Techn. Name: Geophysical Data Fusion for Subsurface Imaging

Tech #: 28

Ref ID: 290

Date Available: 9/30/1996

Past Investment($K): 0

Surveillance and Monitoring-Subsurface Science

Future Investment($K): 0

INDP

Description: The data fusion system combines data from complementary sensors and incorporates geophysical understanding to obtain three-dimensional images of the subsurface. The sensor suite includes geophysical (seismic and electromagnetic induction) and chemical detection techniques. Data from these sensors are processed using rigorous statistics to provide highly resolved subsurface images, such as identification of clay lenses at Savannah River, caliche layers at Hanford, and depth to bedrock and fractures within the bedrock at Oak Ridge. Results of data fusion are used to predict pathways of contaminant migration, assess risk of contaminant migration, and design remedial action.

Expected Capabilities:

Sources: TMS

Notes/ Other Info: Current Gate stage -7

EM-50 Category: RBX

Techn. Name: Facility Mapping and Modeling

Tech #: 191

Ref ID: 44

Date Available:	9/30/1996
Past Investment($K):	1135
Future Investment($K):	0

Surveillance and Monitoring-Data Collection/Samp/Anal

RBX

Description: The Mapping, Characterization, and Inspection System activity provides for the development and demonstration of multi-purpose mobile robotic systems for facility mapping, contaminant characterization, and inspection functions associated with facility S&M. Development will begin with hierarchical data acquisition, data management, and data display for three-dimensional facility mapping, contaminant mapping and record keeping, as well as contamination/configuration tracking. A mobile robotic system will initially perform floor characterization using radiation sensors to accumulate contaminant information for the initial data for the facility mapping system.

Expected Capabilities: Facility mapping provides three dimensional models of facilities and equipment upon which contamination data can be overlayed. These models support further planning activities and allow more directed activites such as decontamination to minimize secondary waste generation. The facility mapping system will provide the capability to capture facility geometry data upon which contaminant data may be mapped. Facility mapping captures characterization data and identifies candidate areas for selective D&D that can then be evaluated relative to minimizing ongoing S&M risks and costs. As activities occur, the facility configuration information will be captured for eventual D&D activity planning, control. and monitoring. This task will interact and incorporate mapping technologies developed through DOE/EM, OST-funded PRDA contracts with Mechanical Technology, Inc., and Coleman Research, as well as University research funded through the Nuclear Engineering program.

Sources: TMS

Notes/ Other Info: Development was terminated after gate 3. The technology was transferred to user or industry to complete.

Techn. Name: Two Dimensional Bar Code Implementation

Tech #: 193	**Date Available:**	9/30/1993	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 1046	**Past Investment($K):**	0	**Future Investment($K):**	0	**RBX**

Description: Two-dimensional bar codes applied to sample containers to improve audit trail.

Expected Capabilities: Two-dimensional bar codes will allow tracking of samples and enable us to maintain an audit trail in the automated chemical analysis system.

Sources: TMS

Notes/ Other Info: In addition to tracking samples, it was suggested that this technology could be useful for recording contents of containers, in the event that remediation is necessary. The technology was terminated after gate 3. Termination reason:Transferred to user or industry to complete.

Techn. Name: Internal Duct Characterization System

Tech #: 187	**Date Available:**	1/4/1995	Surveillance and Monitoring-Instruments/Sensors/Devices	
Ref ID: 42	**Past Investment($K):**	0	**Future Investment($K):** 0	**RBX**

Description: The Internal Duct Characterization System (IDCS) is a remotely-operated inspection system designed to characterize and visually inspect contaminated ventilation duct work. The IDCS consists of a control station, a reel-mounted tether for data communication, and a pipe crawling vehicle. The IDCS vehicle can travel over 200 feet in round ducts six inches in diameter and larger, and in rectangular ducts six inches square and larger. The vehicle visually inspects the interior condition of ducts using a high-resolution color video camera, and has an integrated radiation sensor to detect significant levels of radioactivity. Directional sensors on the vehicle provide information to show vehicle position and attitude, and well as provide information which could be used for as-built mapping of the ductwork. The entire vehicle is made from stainless steel and is designed to be washed down/decontaminated. The IDCS system also provides limited contaminant sampling and decontamination capabilities.

Expected Capabilities: The IDCS vehicle can travel over 200 feet in round ducts six inches in diameter and larger, and in rectangular ducts six inches square and larger. The vehicle visually inspects the interior condition of ducts using a high-resolution color video camera, and has an integrated radiation sensor to detect significant levels of radioactivity. The entire vehicle is made to be washed down/decontaminated. The IDCS system also provides limited contaminant sampling and decontamination capabilities.

Sources: TMS

Notes/ Other Info: This technology was deployed at INEEL-INTEC Liquid Effluent Treatment & Disposal Facility on 1/4/95. Inuktun Services LTD. (small Canadian Firm); Terry Knight; (360)650-0460. Facility Manager: Bob Davis (208)526-1054

Techn. Name: Small Pipe Characterization System (SPCS)

Tech #: 190

Ref ID: 43

Date Available:	9/30/1995
Past Investment($K):	250

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	0

RBX

Description: The SPCS consists of a control computer, a tether for data communication, and a pipe crawling vehicle. The pipe crawler is driven by a dc-motor-powered wheels arranged in a triangular configuration and sprung against the sides of the pipe for traction. The Small Pipe Characterization System provides a means to characterize the internals of previously inaccessible piping systems composed of 2" to 3" pipe.

Expected Capabilities: The Small Pipe Characterization System (SPCS) activity provides for the design, procurement, fabrication. integration, demonstration, and technology transfer of a system for characterizing contaminants in pipes with internal diameters between two and three inches. The configuration of the wheels allows the pipe crawler to maneuver through radiused elbows and to adapt to changing pipe diameters "on the fly." Live color video is transmitted from the camera on the front of the pipe crawler to the control computer. The SPCS is also capable of deploying small sensors such as radiation detectors; however, appropriately sized sensors have not yet been developed.

Sources: TMS

Notes/ Other Info: A licensing agreement to allow Foster-Miller, Inc. to license the technology was signed in FY1995. Foster-Miller has not yet exercised its option to license the technology for commercial production.

Techn. Name: **Three Dimensional Mapping Sensor and Modeling Software**

Tech #: 194 | **Date Available:** 9/30/2003 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 575 | **Past Investment($K):** 1370 | **Future Investment($K):** 0 | **RBX**

Description: The goal of this project was to develop a prototype system to remotely deploy sensors into a workspace, collect surface information, and rapidly build an accurate world model of that workspace. A key consideration was that many target workspace areas are typically hazardous environments, where it is difficult or impossible for humans to enter. Therefore, the system deployment needs to run from local connections, to fully remote with no external connections.

Expected Capabilities: The primary area was to deploy a low cost 3D sensor system to take range data in most environments over a broad area, from a foot to 50 feet from the sensor. A structured lighting system has been used, which uses a laser scan and a video camera receiver. Motorized pan & tilt units provide pointing. The scanning system is computer controlled, with the computer also providing all the processing to create surface models from the raw range data. All components are commercially available, with costs as low as $10,000 for all hardware, including the computer The result of scanning is to build a world model of the environment. This initially contains an accurate 3D geometrical model. Registered camera images can then be mapped onto the surfaces to provide a realistic view of the environment. The ideal is to use the world model to display all sensor data collected within the environment where the user would benefit from knowing its position.

A second area was to deploy an untethered mobile platform with battery power sufficient for both the platform and sensor electronics. A radio Ethernet connection was used to provide communications to the vehicle and all on-board electronics. Video from on-board cameras was also transmitted to the base station and used to tele-operate the vehicle. Range data generated by the on-board 3D sensors was transformed into surface maps, or models. Registering the sensor location to a consistent reference frame as the platform moved through the workspace allowed construction of a detailed 3D world model of the extended workspace.

Other related areas of research and development have included data reduction, fusing data from multi-views, filtering the raw data, editing tools for visualization, auto-segmentation, primitive fitting of raw data for massive data reduction and movement to CAD models, solid modelling, object recognition, and texture mapping.

Sources: TMS

The following are papers presented of this work: Barry RE, Little CQ, Jones, JP, Wilson CW, Rapid World Modelling from a Mobile Platform, IEEE International Conference on Robotics and Automation, Proceedings on CD and WWW, April 20-25, 1997 Feddema JT, Little CQ, Rapid World Modelling: Fitting Range Data to Geometric Primitives, IEEE International Conference on Robotics and Automation, Proceedings on CD and WWW, April 20-25, 1997 Continuation of this work can be seen at: http://www.sandia.gov/isrc/Capabilities/Sensors/Rapid_World_Modeling/rapid_world_modeling.html

Notes/ Other Info: Robotic deployment in hazardous environments, where it is difficult or impossible for humans to enter, will require knowledge of the environment. An accurate 3D world model can be a fundamental part of that knowledge, providing both the user and the robot advantages. The user can view a virtual model of the remote site. The robot can auto-navigate in the environment without hitting things. These abilities will reduce the risks of deployment (avoid collisions) and increase speed (the user can ´see´ what he´s doing). Both of these will affect schedule and compliance

Techn. Name: Compact Remote Operator Console

Tech #: 206	**Date Available:**	9/30/2000	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 726	**Past Investment($K):**	625	**Future Investment($K):**	0	**RBX**

Description: The compact remote operator console provides an economical solution to remote systems control in a portable and modular fashion. It is based on a single box to be wheeled in through a standard size personnel entry door, opened up, and folded out rapidly into a working system. Weight, power consumption, and ease and speed of setup are emphasized. Remote viewing and graphical user interface are provided via flat panel screens arranged as a video cylinder in front of the operator. A control chair is the central focal point, using side consoles for remote viewing and peripheral control inputs. The compact remote operator console will support a wide array of commercial remote systems and manipulators and mobile platforms by providing remote viewing and task control capabilities. It should be used anywhere that there is short-term operation or where cost or facility constraints prevent the use of an installed control room.

Expected Capabilities: The compact remote operator console is designed to minimize impact on facilities where it is used. It is designed to facilitate quick and easy setup of remote systems and to provide remote viewing and tooling/peripheral controls such that almost any commercial remote system control could be quickly and easily integrated into the operator console.

Sources: TMS

Notes/ Other Info: The compact remote operator console was demonstrated 09/30/99 and deployed January 2000 at the INEEL Security Training Facility D&D project. The unit is not currently commercially available

Techn. Name: Video Inspection System for Horizontal Tanks

Tech #: 210 | **Date Available:** 9/30/2001 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 940 | **Past Investment($K):** 485 | **Future Investment($K):** 10 | **RBX**

Description: Several DOE sites need to deploy sensor systems into tanks or tank vaults for inspections, integrity assessments, and other waste and tank characterization measurements. At Oak Ridge National Laboratory, most tanks were emptied and consolidated at the Melton Valley Storage Tanks (MVST) by the end of FY 2000. Prior to handing the MVST over to a privatization vendor for waste processing and transport to a waste handling and packaging plant, DOE must inspect the MVST tank internal conditions and assess sludge volumes. The only access to the tanks is a three-inch sampling port and there are vertical pipes down the centerline of the tanks that obstruct the view.

Expected Capabilities: A camera system will be developed that fits through a three-inch port, has lights, and sufficient articulation to view around obstructions. The Remote Inspection System for MVST will allow DOE to inspect tank internal conditions and assess sludge volumes prior to turning the tanks over to a privatization vendor that will prepare the sludge waste for transport to a waste handling and packaging facility. DOE will also be required to inspect the tanks after completion of the retrieval campaign to ensure that the tanks are still serviceable and to verify the sludge volumes removed.

Sources: TMS

Notes/ Other Info:

Techn. Name: Remotely Operated Vehicle (ROV) System for Horizontal Tanks

Tech #: 201	**Date Available:**	5/24/1999	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 2086	**Past Investment($K):**	700	**Future Investment($K):**	0	**RBX**

Description: Many waste characterization and retrieval tasks can be performed remotely using a mobile vehicle system with on-board manipulator, cameras, and lights. Robotics Crosscutting Program developed a general purpose remotely-operated work platform capable of deployment through 18-inch risers for operation in horizontal waste storage tanks. The system also included a tank riser interface and containment system and an optional waste dislodging and conveyance system. The base vehicle is an adaptation of the Scarab-IIA vehicle built by ROV Technologies, Inc., for reactor maintenance. The resulting system has been referred to as the Scarab-III.

Expected Capabilities: Provides a small remotely operated tracked vehicle system for general purpose tool deployment in hazardous areas. The design has a narrow cross section for deployment through small openings (18-inch risers). Features include a complete integrated system including: vehicle system, waste dislodging and conveyance system, decontamination system, and tank interface and containment. Many DOE underground storage tanks have access penetrations that are 18 inches in diameter and, therefore, are not large enough to deploy large vehicle systems like the Houdini. A smaller vehicle system is needed that can deploy waste retrieval, sampling and inspection tools into these tanks

Sources: TMS

Notes/ Other Info: The vehicle system and waste dislodging end-effector system cold testing were completed in FY98. The vehicle was deployed in ORNL FFA Tank T-14 in May, 1999 where a successful sampling and inspection campaign was completed.

Techn. Name: Remote Underwater Characterization System (RUCS)

Tech #: 203

Ref ID: 2151

Date Available:	9/15/1999
Past Investment($K):	506
Future Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

RBX

Description: The Remote Underwater Characterization System (RUCS) is an underwater characterization system designed to perform tasks such as characterization and small parts retrieval. It is based on a small, commercially-available, submersible vehicle. The small size of the vehicle allows it to operate in areas where access is tight or where maneuvering room is limited.

Expected Capabilities: The Underwater Characterization System (RUCS) is based on the ´Scallop´ remotely operated vehicle, which is produced by Inuktun Services, Ltd. in British Columbia, Canada. The system is very inexpensive when compared to others of similar capability. The vehicle has underwater lights and a front color camera. It is capable of operating at depths up to 100 feet feet and can travel at speeds of up to 2 knots. The Robotics Crosscutting Program added an on-board compass, depth sensor, and gamma radiation detector. An ´auto-depth´ control feature was also implemented to allow the vehicle to ´hover´ at a user-selected depth. A second version includes a small manipulator and an ultrasonic probe. Two variable-speed horizontal thrusters provide for forward and backward motion as well as steering via a joystick control on the operator console. The vehicle is slightly positively buoyant so that it will float to the surface in the event power is lost. A single vertical thruster is used to drive the vehicle to depth. The system is controlled through microprocessors (one on the vehicle and one in the control station) via RS-485 serial communication. The added depth sensor will be used to control the depth of the vehicle so that the operator can select a depth and a control algorithm will adjust the vertical thruster to change depth and hold a specified depth. A waterproof MGP Instruments GM tube radiation detector is being incorporated onto the underside of the vehicle so that the operator can ´fly´ the vehicle up to underwater features and see radiation levels from 5 mR to 999R displayed at the control station.

Sources: TMS

Notes/ Other Info: Full scale demonstration, which continued as a deployment, was completed 8/25/98 at the TRA-660 facility at INEEL. The technology was demonstrated/deployed within current D&D activity as part of the D&D Focus Area INEEL Large Scale Demonstration and Deployment Project (LSDDP). This system is expected to cost less than the current baseline technology employed in underwater D&D operations, which is a pan and tilt camera on a long pole. The addition of the auto-depth feature will fill a technology gap since this capability is not known to be available on any underwater vehicles costing less than $100K.

Techn. Name: Structured Light

Tech #: 192 | **Date Available:** 2/28/1997 | Surveillance and Monitoring-Physical Barriers

Ref ID: 367 | **Past Investment($K):** 1175 | **Future Investment($K):** 0 | **RBX**

Description: A Topographical Mapping System (TMS) was developed by Oak Ridge National Laboratory (ORNL) and Sandia National Laboratories (SNL) for use at the Fernald K-65 silos. This system used the structured light technique to determine range from sensor modules to illuminated surfaces. Contour maps of the waste surfaces were generated from the integration of numerous data points. A version of the TMS suitable for deployment at Hanford was completed in 1997. Hanford requirements included higher radiation, higher pH, and explosive atmospheres. This system was developed by ORNL and Mechanical Technology Incorporated (MTI) following CRADAs between MTI and both ORNL and SNL. MTI later sold the technology to Foster-Miller, Inc. The system became commercially available in 1997.

Expected Capabilities: ORNL developed the original Topographical Mapping System deployed at Fernald, based on a proof-of-principle demonstration conducted by SNL of the structured light technique. ORNL designed and built the 3 mapping sensor modules and controllers that were deployed at Fernald, as well as an automated data acquisition and display graphical user interface. This design was later modified to withstand the higher radiation and pH and explosive atmospheres at Hanford. That modified system was developed by Mechanical Technology Incorporated (MTI) following CRADAS with ORNL and SNL.

Sources: TMS

Notes/ Other Info: Deployed at FN Silos 1&2 to Certify CERCLA milestones in Dec. 1991; Dennis Nixon Proj. Mgr.; Ph. #(513)648-4800 ORNL Tech Memo #ORNL TM-12185; Mechanical Technologies Inc. (MTI), John Wagner 518 -785-2800; was under OST #923. Transfered to Tanks Focus Area (TFA) for deployment. See OST Ref.130

EM-50 Category: SCFA

Techn. Name: Verification of Subsurface Barriers/Moisture Detection

Tech #: 134	**Date Available:**	9/30/1994	Caps and Covers-Caps and Covers		
Ref ID: 585	**Past Investment($K):**	383	**Future Investment($K):**	0	**SCFA**

Description: This project involves the design of a sub-surface barrier performance monitoring system that will indicate when liquid contaminants are migrating past the barrier system so that corrective actions can be taken.

Expected Capabilities: Subsurface barriers are plagued by the same old question that all subsurface barriers are subject to: 'How can you be certain there are no holes in the barrier?' To be most effective the barriers should be continuous and depending on use, have few or no breaches. A breach may be formed through numerous pathways including: continuous grout application, from joints between panels and from cracking due to grout curing or wet-dry cycling. No suitable method exists for the verification of an emplaced barrier's integrity. The large size and deep placement of subsurface barriers makes detection of leaks challenging. This becomes magnified if the permissible leakage from the site is low. Detection of small cracks (fractions of an inch) at depths of 100 feet or more has not been possible using existing surface geophysical techniques. Compounding the problem of locating flaws in a barrier is the fact that no placement technology can guarantee the completeness or integrity of the emplaced barrier. The sub-surface barrier performance monitoring system is designed to detect moisture increases above baseline after the barrier has been installed to indicate when the barrier integrity is breached.

Sources: TMS; Tech ID: 585

Notes/ Other Info: This technology is applicable to LTS for the long term monitoring of the performance of subsurface barriers. This technology was terminated, development completed through Gate 6.

Techn. Name: Capillary Barrier

Tech #: 170 | **Date Available:** 9/30/1997 | Caps and Covers-Caps and Covers

Ref ID: 1717 | **Past Investment($K):** 375 | **Future Investment($K):** 0 | **SCFA**

Description: Surface covers are an important component in the isolation strategy of waste management methods. Landfills, surface impoundments, waste piles, and some mine tailings are required to be covered with an engineered cover or cap upon closure. Conventional covers can be expensive, difficult to construct, and of questionable long-term performance. Capillary barriers, consisting of fine-over-coarse soil layers, have been suggested as an alternative component for surface covers, but they have not been widely applied, and their performance has not been fully demonstrated. Although a relatively simple configuration, a capillary barrier should result in a long-lived, easily constructed, and low-cost barrier in comparison with many conventional cover systems.

Expected Capabilities: This project involves demonstrating capillary barrier landfill cover concepts in a cooperative effort with the Bureau of Land Management (BLM) at the Lee Acres landfill near Farmington, NM. The design of the capillary barrier includes laboratory characterization of candidate soils, numerical modeling, performance predictions using advanced unsaturated flow tools used in previous Sandia National Laboratory capillary barrier research, and specification and installation of in situ instrumentation to monitor the performance of the deployment. The installation at Lee Acres was completed in May 1997.

Sources: TMS; Tech ID: 1717

Notes/ Other Info: This technology may be applicable to improved performance of caps during LTS. This technology was terminated, development completed through Gate 6.

Techn. Name: **Electrical Methods for Evaluating & Monitoring Geomembrane Caps**

Tech #: 46
Ref ID: 3050

Date Available:		Caps and Covers-Caps and Covers		
Past Investment($K):	195	**Future Investment($K):**	176	**SCFA**

Description: Lawrence Livermore National Laboratory (LLNL) has pioneered the development of electrical imaging techniques, including electrical resistance tomotraphy (ERT) and electrical impedance tomography (EIT). One of the technologies which has grown out of this work is excitation of the mass (EOM) for current imaging. Persons at LLNL have been working for a years, using internal LLNL funding, to develop EOM for detecting leaks in geomembrane lined waste storage ponds (Binley et al, 1997). It is believed that a modification of this technology can be used to detect and locate leaks in geomembrane lined landfill caps.

Expected Capabilities: Excitation of Mass (EOM) has been used experimentally to detect and locate leaks in a geomembrane lined pond. We propose adapting this EOM technology to detect leaks (breaks, tears, seam separations) in geomembrane liners used in landfill caps. We also propose to develop methods whereby this technology can be used as a long term monitoring tool for geomembrane liners used in landfill caps. EOM is a technology that sends electrical current through the geomembrane. Current will flow only where the liner is torn and this current sets up a potential field which can be used to determine the leak location. An important aspect of the method is that it lends itself to long term monitoring using simple and remotely controlled instrumentation.

Sources: TMS; Tech ID: 3050

Notes/ Other Info: Identified by SCFA as a technology related to LTS. This technology was terminated, awaiting a decision on deployment.

Techn. Name: **Engineering Design Guidance for Long Term Cover Performance Systems**

Tech #: 43
Ref ID: 3052

Date Available:	9/30/2002	Caps and Covers-Caps and Covers		
Past Investment($K):	450	**Future Investment($K):**	400	**SCFA**

Description: This guidance document is the result of a developed engineering procedure that can be used to adequately design and construct landfill closures with flexibility to take into account the site specifics of each site. This guidance is more than adequate to attain current recommendations for regulatory compliance, meeting RCRA/CERCLA requirements.

Expected Capabilities:

Sources: TMS; Tech ID: 3052; Attachment E - FY 2002 PEG Report

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Coupled Environmental Process and Long Term Closure Cover Design

Tech #: 45

Ref ID: 3055

Date Available:

Past Investment($K): 134

Caps and Covers-Caps and Covers

Future Investment($K): 149

SCFA

Description: Closure of radioactive waste disposal cells at DOE Sites is imminent and will likely continue for at least the next decade. On the basis of research conducted, a monolayer-evapotranspirative (ET) or similar closure cover, is the preferred closure technology at the Nevada Test Site (NTS) and Sandia National Laboratories (SNL) and other arid sites. Inherent in such closure covers is the presumed ability to perform according to design for long periods of time after maintenance associated with institutional control has ceased. Uncertain is the affect of coupled environmental processes and changes. This proposal will examine and quantify the affects of coupled processes and changes to provide a better understanding of the long-term performance of the closure cover. With this understanding, the closure covers can be better designed to accommodate the affects of coupled processes.

Expected Capabilities:

Sources: TMS; Tech ID: 3055

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Long Term Waste Stabilization Design for Long Term Cover Systems

Tech #: 44

Ref ID: 3056

Date Available:

Caps and Covers-Caps and Covers

Past Investment($K): 1250

Future Investment($K): 200

SCFA

Description: The overall goal of this task will be the production of a generic, risk and cost based design methodology for the evaluation and selection of physical stabilization options for Long-term Cover Systems. The evaluation and selection process will be based upon the impact of the waste physical stabilization options upon long-term structural stability, subsidence, long-term active maintenance, cost effectiveness, and the associated risk as evaluated against the DOE Order O435.1 Performance Objectives through integration with the Performance Assesment process. The results of this task will feed into the SCFA Long Term Capping Design Guidance Strategy.

Expected Capabilities:

Sources: TMS; Tech ID: 3056

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Cover Performance Verification & Long-Term Monitoring System

Tech #: 47	**Date Available:**		Caps and Covers-Caps and Covers	
Ref ID: 3068	**Past Investment($K):**	520	**Future Investment($K):** 325	**SCFA**

Description: Capping and cover systems are needed in the DOE complex for the closure of landfills, waste sites, high-level waste tanks, and other locations where contaminants will remain after cleanup is completed. The intent of verification and monitoring is to verify the overall performance of the cover through the data provided by long-term monitoring system. Long term monitoring is the method and cover performance verification is the objective. Consideration of long-term verification and monitoring is also a key element in the establishment of site closure plans and long-term environmental stewardship commitments. The term ´long term´ reflects the sustainability and durability of the remedial system performance. The time reference is the 100s of years that are necessary when dealing with long-lived radionuclides. A significant technical challenge in this task is data set integration for spatial and temporal information.

Expected Capabilities:

Sources: TMS; Tech ID: 3068

Notes/ Other Info: Identified by SCFA as a technology related to LTS. This technology was terminated, awaiting a decision on deployment.

Techn. Name: Alternative Landfill Cover

Tech #: 22

Ref ID: 10

Date Available:	9/30/1999
Past Investment($K):	8717

Caps and Covers-Landfills

Future Investment($K):	500

SCFA

Description: The alternative landfill cover demonstration is a large-scale field test at Sandia. Two baseline covers were constructed side-by-side with four alternative cover designs for comparison based on performance, cost, and ease of construction. The covers are being monitored for all water balance variables and supporting data. This field data will be compared with results from predictive computer models for validation of the models and for projection of the long-term performance of alternative covers. Alternative cover designs resist drying and cracking that impairs cover performance.

Expected Capabilities: The ALCD is testing innovative landfill covers using currently accepted EPA cover designs as baselines. These covers are installed and instrumented in a side-by-side demonstration. Each test plot is 300 ft long; peaked in the middle with 150 ft sloping at 5% toward the west and the other 150 ft half sloping at 5% towards the east. The eastern half of each test plot will be evaluated under ambient conditions and the western side evaluated under ´stressed´ conditions controlled by a rain simulation system. The covers will be evaluated and compared based on construction, cost, and performance criteria. Some of the alternative designs will emphasize such things as unsaturated hydraulic conductivity, increased water storage potential to allow for eventual evaporation, and increased transpiration through engineered vegetative covers. The alternative covers were designed to take advantage of local materials to allow for easier construction of the covers at substantial cost savings.

Sources: TMS, Tech ID: 10

Notes/ Other Info: This technology relates to the long-term performance of the cover.

Techn. Name: Migration Barrier Covers for Mixed Waste Landfills

Tech #: 137

Ref ID: 598

Date Available:

Caps and Covers-Landfills

Past Investment($K): 0

Future Investment($K): 0

SCFA

Description: Field-tested migration barrier cover designs, tailored to the climate, can serve as the sole containment technology or as a component of an integrated barrier system that incorporates other barrier concepts, along with cover, to contain wastes. In addition, the hydrologic control exerted by the cover can be used to establish optimum moisture conditions in the waste backfill to improve performance of other treatment technologies such as in-situ vitrification (ISV), vapor extraction, and other in-situ treatment technologies. Relative to the excavate and re-bury option, containment with field-tested migration barrier designs can reduce remediation costs 10-10,000 times and still ensure regulatory compliance.

Expected Capabilities: The objective of this project is to provide field-tested capping alternatives, including the EPA RCRA cap, and calibrated water balance models that can be used in the assessment phase of the remedial investigation and as a component of the corrective measures study for selecting remediation alternatives for landfills. The goal is to ensure that cost-effective capping technologies are available so that cap design can be selected based on the level of hydrologic control needed at the site. Over the past eight years, parallel and collaborative research and development by LANL, PNL, INEL, U.S. Department of Agriculture-Agriculture Research Service (USDA-ARS), USGS, and the Uranium Mill Tailings Remedial Action (UMTRA) program have explored several alternative long-term migration barrier cover technologies for interim stabilization and final closure of radioactive waste landfills in arid sites. These barrier technologies have addressed erosion control, deep percolation, and biological intrusion using engineered covers constructed of synthetic and/or natural geologic materials. Underlying hydrological and biological phenomena were used to design barriers that control the fate of precipitation falling on the site.

Sources: TMS; Tech ID: 598

Notes/ Other Info: This technology is designed to provide the best performing covers during LTS. This technology was terminated after Gate 6, awaiting decision for deployment.

Techn. Name: Decision Support System to Select Landfill Cover System

Tech #: 213

Ref ID: 603

Date Available:		Caps and Covers-Landfills		
Past Investment($K):	0	Future Investment($K):	0	SCFA

Description: Containment technologies, including surface caps, are essential to reducing the potential for contaminant migration from a landfill by an alteration of the surface and/or subsurface soils. The process of selecting contaminant cover technologies for landfills requires consideration of many complex and inter-related technical, regulatory, and economic issues. A decision support system is needed to integrate the knowledge of experts from scientific, engineering, and management disciplines to help in selecting the 'best' capping practice.

Expected Capabilities: The objective of this technology is to provide risk managers with a defensible, objective way to select capping alternatives for remediating radioactive and mixed waste landfills. The objective will be achieved through a joint project between LANL and USDA-Agricultural Research Service (ARS) by developing a multi-objective decision-making software system (DSS), with embedded simulation models, to design and evaluate engineered surface barriers for mixed waste landfills. The data collected from the Migration Barrier Covers for Mixed Waste Landfills project will be used to evaluate the DSS.

Sources: TMS; Tech ID: 603

Notes/ Other Info: This technology is designed to select the best capping for the application during LTS. This technology was terminated, awaiting decision for deployment.

Techn. Name: **Alternative Cover and Monitoring System for Landfills in Arid Environments**

Tech #: 42

Ref ID: 2924

Date Available:	12/1/2000	Caps and Covers-Landfills	
Past Investment($K):	743	**Future Investment($K):**	0

SCFA

Description: The baseline closure technology is a layered closure cover recommended under the Resource Conservation and Recovery Act (RCRA). A typical layered closure cover, which is designed to block water from infiltrating into disposed waste, is subject to failure in arid environments and has a limited design life. Clay layers tend to desiccate and crack, and artificial impermeable membranes tend to degrade, rip, or puncture. An alternative closure cover consisting of a single layer of native soil that stores infiltrated water and then allows that water to be extracted through evaporation and plant transpiration has been deployed on disposal unit U-3ax/bl at the Area 3 Radioactive Waste Management Site (RWMS) at the Nevada Test Site (NTS). A string of sensors that measure the amount of water in the soil column is installed at four locations in the monolayer-evapotranspiration (ET) closure cover. A facility designed to monitor and evaluate the performance of the alternative closure cover has also been deployed adjacent to the U-3ax/bl disposal unit. A string of sensors that measure the amount and tension of water in the soil column is installed in each of eight drainage lysimeters that compose the facility. Each lysimeter contains approximately the same thickness of soil as the U-3ax/bl closure cover, and each pair of lysimeters has a different vegetation scheme, including bare and a mix of indigenous species identical to the mix of species used on the actual closure cover. Funded since Fiscal Year 1999, the first two years of the project included characterization of waste disposed in U-3ax/bl and of geotechnical properties of an existing operational closure cover, design, and regulatory acceptance of the monolayer-ET concept and design. The objectives of work in Fiscal Year 2001 were to construct the monolayer-ET closure cover and the performance monitoring system, and to start collection of data. The vegetated monolayer-ET closure cover is effective in keeping water from disposed waste when evaporation and plant transpiration exceed precipitation. Investigations, including artificially raining on the lysimeters, are being planned that will better define the actual performance envelope relative to precipitation. Other investigations designed to better define the envelope of performance will likely include varying soil texture and surface vegetation. The system should continue to be effective provided that the closure cover remains relatively intact, the cover is vegetated with a sufficient number and type of plant species, and the environmental processes acting on the closure cover over the long term are not destructive beyond the performance envelope. The deployment is now starting the phase of data collection. Data from both the U-3ax/bl closure cover and the drainage lysimeter facility are collected on site and can be downloaded directly to Las Vegas via a telephone link. The durability of the various sensors is one uncertainty. Should the various sensors fail to a degree that data analysis and interpretation are compromised, then the sensors will be replaced.

Expected Capabilities:

Sources: TMS; Tech ID: 2924

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Fixation Of Soil Surfaces Using Natural Vegetable Starchs

Tech #: 161	**Date Available:**	Caps and Covers-Other Units		
Ref ID: 1271	**Past Investment($K):** 0	**Future Investment($K):** 0	**SCFA**	

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 1271

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to covers and containment during LTS.

Techn. Name: Rapid Bioassessment Technologies for Cost Effective Risk at CERCLA Sites

Tech #: 150	**Date Available:**	Ecosystem Monitoring-Field Data		
Ref ID: 674	**Past Investment($K):** 0	**Future Investment($K):** 0	**SCFA**	

Description: The development of rapid bioassessment technologies could provide easily applied and economical tools useful in identifying, measuring, and determining the extent of waste site impacts. Some of these methods could also be useful for other tasks such as the National Pollutant Discharge Elimination System's outfall monitoring and watershed management.

Expected Capabilities: The objective of this task is to develop fast, economical methods for using information from aquatic and terrestrial animals and plants to indicate the extent of contamination and environmental risks at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. There are four subtasks within this task: (1) development of biotic indices based on the attributes of fish and invertebrate communities to measure the degradation of streams near waste sites, (2) development of a bioassay method using tree leaves to map the extent of groundwater tritium contamination near waste sites, (3) development of procedures that use the germination success of native plants to assay mineral and organic toxicants found in wastes sites and, (4) development of assay methods that use changes in the survival, body weight, and behavior of earthworms to assay toxicants in waste sites.

Sources: TMS; Tech ID: 674

Notes/ Other Info: This technology has the capability to monitor the ecosystem for changes during LTS. This technology was terminated after Gate 4 because it was a lower priority than could be covered by available funding.

Techn. Name: Smart Sampling

Tech #: 108

Ref ID: 162

Date Available:	9/1/1999
Past Investment($K):	2007

Information Management-Data Collection

Future Investment($K):	0

SCFA

Description: Smart Sampling is divided into three integrated technical product lines: 1) information management and visualization, 2) advanced geostatistical applications, and 3) economic risk-based decision analysis. This process has two functional lines: technology development and technology deployment. Smart Sampling uses geostatistical simulation to generate maps or 3-dimensional pictures that display the likelihood of exceeding design or performance crite-ria at a specific site as a function of currently available information, such as the likelihood of exceeding a regulatory action level for a particular contaminant. Emphasis is on integrating the ability to perform Smart Sampling with existing hardware and software systems at individual sites.

Expected Capabilities: With Smart Sampling, geostatistical simulation techniques are applied to existing site data and maps are generated which model the probability of contamination exceeding a regulatory threshold across a site. This probabilistic approach requires stakeholders and regulators to agree on the level of risk they are willing to accept in determining both an action level for the contamination and the probability of failing to meet that level. The acceptable probability of leaving behind contaminated soil is applied to the probability map. Every location on the map exceeding the acceptable probability is targeted for remediation. Together these locations comprise the remediation map and can be displayed as a computerized mapping system commonly referred to as a Geographic Information System (GIS). Integrating site data with the chosen action levels and range of probabilities, the maps and their corresponding cost curves allow regulators and stakeholders to see clearly the economic consequences of their decisions. If the uncertainty, or cost, of achieving an acceptable clean-up level is too high, it may be possible to reduce these factors by taking additional soil samples. The maps can be used to determine optimal locations for the collection of additional samples.

Sources: TMS; Tech ID: 162

Notes/ Other Info: This technology may be applicable to site characterization for LTS.

Techn. Name: Time Domain Reflectometry with Waveguides

Tech #: 151	**Date Available:**	4/1/2001	Physical Barriers-Subsurface Science	
Ref ID: 704	**Past Investment($K):**	0	**Future Investment($K):** 0	**SCFA**

Description: This technology provides real-time monitoring of barriers on surface and subsurface. This monitoring system will give the regulators, waste disposal structure operators/owners, and the public assurance that the barrier system is performing as designed.

Expected Capabilities: The objective of this task is to design a sub-surface barrier performance monitoring system which will indicate liquid contaminants are migrating past the barrier system so that corrective actions can be taken. Sub-surface barrier systems will operate below underground waste disposal structures at various DOE sites to prevent the transport of chemical and radioactive contaminants into soil and water table.State and federal regulators are requiring that the sub-surface barrier system have a detection or performance monitoring verification system in place. The sub-surface barrier performance monitoring system will detect moisture increases above baseline after the barrier system has been installed.

Sources: TMS; Tech ID: 704

Notes/ Other Info: This technology may be utilized monitor the performance of barriers during LTS. This technology was terminated after Gate 4, awaiting a decision for further deployment.

Techn. Name: Subsurface Barrier Emplacement

Tech #: 23	**Date Available:**		Physical Barriers-Waste Forms		
Ref ID: 11	**Past Investment($K):**	2805	**Future Investment($K):**	0	**SCFA**

Description: The Subsurface Barrier Emplacement project has adapted vertical barrier equipment and technologies currently used in civil engineering applications to emplace horizontal barriers capable of confining leaking waste sites. The approach integrates different technologies (subsurface access techniques such as directional drilling, barrier emplacement technologies, barrier materials, barrier verification of continuity, and post barrier emplacement monitoring) to install an impermeable barrier beneath a waste site and then verify its integrity. The barrier, which is composed of a grouting material, must be emplaced without disturbing the waste site to prvent the spread of contamination. The primary benefit of a subsurface barrier system is that the waste volume will remain fixed, allowing additional time to develop remedial treatments. In addition, remedial alternatives may be enhanced by the installed barrier, and the timing of cleanup becomes less critical.

Expected Capabilities: The Subsurface Barrier-Emplacement consists of placing a relatively impermeable barrier beneath an existing waste site. The barrier, which is composed of a grouting material, has to be emplaced without disturbing the waste form. Two emplacement technologies have been tested: permeation and jet grouting. Permeation grouting injects a low-viscosity grout into the soil at low pressure, filling the voids without significantly changing the soil structure or volume. In contrast, jet grouting injects grout at a high pressure and velocity. This action completely destroys the soil structure. The grout and the soil are intimately mixed, forming a homogenous mass. Initially, feasibility of each technique was evaluated, followed by evaluation of design parameters, such as borehole separation, depth, limitations, etc.

Sources: TMS; Tech ID: 11

Notes/ Other Info: This technology places a barrier beneath the waste until remediation is complete or for potential long-term application. Terminated after Gate 6, transferred to industry to complete.

Techn. Name: In Situ Redox Manipulation

Tech #: 65	**Date Available:**	9/30/2000	Physical Barriers-Waste Forms		
Ref ID: 15	**Past Investment($K):**	5509	**Future Investment($K):**	0	**SCFA**

Description: n Situ Redox Manipulation creates a treatment zone within an aquifer for destruction or immobilization of contaminants by reducing iron molecules present in ferric clays. Multiple methods of iron reduction are being tested including dithionite and microbial reductants. As the groundwater flows through the treated zone, the reduced iron molecules become sites for the reduction of redox-sensitive metals, radionuclides, and organics.

Expected Capabilities: Controlling the oxidation-reduction (redox) potential of the unconfined aquifier in situ methods for immobilizing inorganic contaminants (metals, inorganic ions and radionuclides) and destroying organic contaminants (primarily chlorinated hydrocarbons). The concept is to create a permeable treatment barrier by injecting reagents and/or microbial nutrients into the subsurface. The types of reagents and nutrients injected will be selected based on their ability to make the aquifier reduce, thereby destroying or immobilizing specific contaminants. This process is referred to as In Situ Redox Manipulation (ISRM). Although the proposed target of this technology is chromate contamination in the Hanford 100 Areas, the concept should be applicable to a range of other contaminants, including uranium, technetium, chlorinated solvents, and energetic compounds. As part of the pre-experiment, site characterization, analyses of physical, geochemical, and microbiological data were conducted on sediment samples collected from new wells installed by sonic drilling. Mathematical models were used in conjunction with reagent and site characterization information to define nominal specifications for the field experiments. The design models accounted for advection, dispersion, degradation, and transformation processes. The
model examined and evaluated the proposed field operations that will deliver an effective concentration range of sodium dithionite in the desired aquifier volume for a period of time that allows the targeted ferric iron to be reduced. An additional pilot-scale demonstration is proposed to occur in late FY96 or FY97 at the Hanford 100-D Area. The dimensions in the nominal design of the pilot-scale ISRM treatment zone are 200 feet long by 50 feet wide. The treatment zone would be emplaced within the chromium plume at the 100-D Area, downgradient from the 500 ppb isopleth. The maximum concentrations of chromium in the 100-D Area groundwater in May 1992 was 2,020 ppb. The approach taken for the barrier emplacement is similar to that used for the FY95 ISRM field experiments in the 100-H Area. A long linear barrier will be created by coalescing a number of smaller reduced zones.

Sources: TMS; Tech ID: 15

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Viscous Liquid Barrier

Tech #: 57	**Date Available:**	6/12/2000	Physical Barriers-Waste Forms		
Ref ID: 50	**Past Investment($K):**	9708	**Future Investment($K):**	0	**SCFA**

Description: Two of the liquids investigated, Colloidal Silica (CS) and PolySiloXane (PSX), undergo extreme increase in viscosity after mixing their component additives. When injected into the subsurface, these viscous liquids form impermeable barriers that are biologically and chemically inert, are unaffected by filtration, and pose no health hazard FDA-approved for food contact). Barriers using CS and PSX have been constructed successfully in sediments of sands and silts.

Expected Capabilities: This Viscous Liquid Barrier (VLB) technology uses a viscous liquid grout injected into the subsurface where it gels to form an hydraulic barrier which isolates contaminated soils or waste materials so that the contaminants are prevented from further migration into the surrounding ´clean´ soils. Low permeable barriers can be used to prevent the spread of contaminants in the soil and groundwater. The VLB technology works by filling large and small pore spaces in the soil with the viscous liquid grout, then the grout gels in place to form the barrier. These barriers may be used as a means of long-term containment or as a temporary containment until the contamination source is removed or degraded.

Sources: TMS; Tech ID: 50

Notes/ Other Info: This technology contains the waste form during and after remediation. Terminated after Gate 4 because lower priority than could be covered by available funding.

Techn. Name: Frozen Soil Barrier

Tech #: 59	**Date Available:**	9/30/1998	Physical Barriers-Waste Forms		
Ref ID: 51	**Past Investment($K):**	5206	**Future Investment($K):**	0	**SCFA**

Description: The Frozen Soil Barrier is a temporary in situ containment technology. A twelve foot-thick barrier is formed by circulating refrigerant through dual tube boreholes spaced around the area to be contained, which freezes the soil moisture and reduces permeability. This technology was deployed at a radioactively contaminated reactor pond site.

Expected Capabilities: This technology induces soil freezing artificially to freeze moisture, thereby reducing its hydraulic conductivity and holding the contaminant plume inside the boundaries of the freeze. The technology of using refrigerants to freeze soils has been employed in large- scale engineering projects for a number of years. This technology bonds soils to give load-bearing strength during construction; to seal tunnels, mine shafts, and other subsurface structures against flooding from groundwater; and to stabilize soils during excavation. Examples of modern applications include several large subway, highway, and water-supply tunnels. This technology requires placing freeze pipes into the subsurface. Circulating refrigerant through dual tube boreholes spaced around the area to be contained forms a 4-to-6-feet- thick barrier around the waste, which can be maintained indefinitely. These pipes are used to transfer a brine solution which acts as the heat transfer media to the subsurface to remove heat from the soil. Above-ground refrigeration plants capable of handling the heat loads of the trench soil will cool the brine to the required temperatures to maintain the frozen barrier. Frozen soil barriers that provide complete containment (such as a "V" configuration) are formed by drilling and installing refrigerant piping (on 8-feet centers) horizontally at approximately 45 degree angles for sides, and vertically for ends, and then recirculating an environmentally-safe refrigerant solution through the piping to freeze the soil pore water. Freeze plants are used to keep the containment structure at subfreezing temperatures. Advantages of this technology include: -It can provide complete containment. -It uses benign materials (water/ice) as a containment medium. -Frozen barriers can be readily removed (by thawing). -Frozen barriers can be repaired in situ (by injecting water into the leakage area).

Sources: TMS; Tech ID: 51

Notes/ Other Info: This technology may provide temporary to indefinite containment of waste form.

Techn. Name: Innovative Grout

Tech #: 73

Ref ID: 63

Date Available:	9/30/1997
Past Investment($K):	106

Physical Barriers-Waste Forms

Future Investment($K):	0

SCFA

Description: The Innovative Subsurface Stabilization Project is a series of applied research tests involving stabilizing simulated buried waste sites with grouting agents using jet-grouting techniques. The purpose of this research is to prove that the technology is valid for application to hot buried waste sites. The basic jet-grouting technique is to make the waste into a solid monolith, which is the same effect as simultaneous horizontal and vertical barriers while also providing stabilization against subsidence. The monolith is created by jet grouting adjacent columns with the grouting material such that the soil-and-waste matrix forms a solid monolith, which should be an improved containment over a combination of vertical and horizontal barriers.

Expected Capabilities:

Sources: TMS; Tech ID: 63

Notes/ Other Info: This technology improves the ability to stabilize the waste form.

Techn. Name: Chemically Reactive Backfills

Tech #: 103 | **Date Available:** | Physical Barriers-Waste Forms

Ref ID: 124 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: This program consists of three parts. The first part of this program is a demonstration of the stabilization capacity of the chemically reactive materials that will constitute the barrier or backfill. Some of the materials that have been tested and may be specified for use in these backfills include clays, zeolites, phosphates, cements, and organic additives. Materials will be designed for stabilization of radionuclides and hazardous metals. In addition, efforts will be made to develop materials for stabilization of sodium salt species and for in situ destruction of organic compounds. Engineering properties of the backfill materials will be determined. Some materials have already been demonstrated in the laboratory and are suitable in a wide range of conventional construction applications. Additional materials will be developed and evaluated for the specific contaminants encountered in the demonstration sites. The second part of this program involves demonstrating methods of emplacing these materials in contaminated environments. Emplacement methods that will be evaluated include slurry techniques used for Consolidate Low Strength Materials in the construction industry and an innovative soil by hydrofracturing technique (horizontal subsurface barrier.) The third part involves performance modeling of the waste form. Verification of the modeled performance will utilize actual field data collected at the demonstration sites. Technology involved in the performance modeling includes innovative modifications to environmental transport codes currently in use at the Savannah River Technology Center.

Expected Capabilities:

Sources: TMS; Tech ID: 124

Notes/ Other Info: This technology may be used for LTS in maintining the barrier and monitoring performance of the waste form. Terminated after Gate 5, awaiting decision for further deployment.

Techn. Name: Subsurface Containment Systems Repair

Tech #: 104

Ref ID: 149

Date Available:

Past Investment($K): 2200

Physical Barriers-Waste Forms

Future Investment($K): 0

SCFA

Description: The following cost-effective and minimally intrusive cap-repair techniques are currently under evaluation and development: -Injection grouting of low-viscosity colloidal silica (gel) or polysiloxane (polymer): the low viscosity material will be injected at the interface of the drainage and compacted clay layers (overlaying layers are left in place) so that cracks in the compacted clay layers are sealed. This technology may also have applicability to the repair of flexible membrane liners. -Geosynthetic clay-liner placement: the vegetative and drainage layers are excavated while the clay barrier is left in place. Then the geosynthetic clay-liner is placed over the areas of cracked clay, and the vegetative and drainage layers replaced. Laboratory pilot-scale testing of these technologies is being conducted in Fiscal Year 1996 (FY96). Field-scale testing at SRS is scheduled for FY97.

Expected Capabilities:

Sources: TMS; Tech ID: 149

Notes/ Other Info: This technology may be used to ensure long term integrity of the barrier. Terminated after Gate 4, awaiting decision for further deployment.

Techn. Name: Barriers and Post-Closing Monitoring

Tech #: 123

Ref ID: 523

Date Available:

Past Investment($K): 0

Physical Barriers-Waste Forms

Future Investment($K): 0

SCFA

Description: This task objective of the Barriers and Post-Closure Monitoring technology is to design, construct, install, field test, and evaluate an automated state-of-the-art soil moisture monitoring system for measuring the hydrologic performance of migration barriers and advanced surface covers for remediating landfills.

Expected Capabilities: This technology will supply needed information to waste site investigators on hydrogeologic parameters and chemical specific concentrations in the subsurface. Moisture content and pore pressure measurements in unsaturated soils are critical parameters for inclusion in fate and transport modeling, and also in risk assessment evaluations. Since this technology is based on a cone penetrometer application, the speed of collecting the data is greatly enhanced compared to conventional drilling and sampling methods. Therefore, significant cost savings result. Three brands of TDR will be evaluated, including one manufactured in Germany, one by Campbell Scientific, and one manufactured in Logan, Utah. Performance, reliability, and cost of each of the technologies will be compared and documented. Radiation, volatile organic compounds, or other chemical detectors may also be evaluated as possible components of an integrated monitoring system.

Sources: TMS; Tech ID: 523

Notes/ Other Info: This technology was designed to monitor the long term post-closure performance of barriers and covers. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: In Situ Containment and Stabilization of Buried Waste

Tech #: 131

Ref ID: 565

Date Available:

Past Investment($K): 0

Physical Barriers-Waste Forms

Future Investment($K): 0

SCFA

Description: This technology aims to develop, demonstrate, and implement advanced grouting materials for in-situ stabilization of contaminated soils and the placement of impermeable, highly-durable subsurface barriers.
The development effort focuses on cementitous and soil cement mixtures compatible with commercially available placement techniques.

Expected Capabilities: Formulations for use in an arid environment were optimized and characterized. The major placement techniques considered were jet grouting, soil mixing, and soil sawing. Cementitious grouts with permeabilities of the order of 10 to the -10 and -11 cm/s suitable for monolithic grout subsurface barriers were developed. Permeability after accelerated leaching and repeated wet-dry cycles was of the order of 10 to the -10 and -9 cm/s. The results compare favorably with EPA permeability limit of 10 to the -7 cm/s for landfills. The developed superplacticized grouts and soil cements have significantly superior mechanical, physical, and durability properties than those of conventional formulations. The permeabilities are two to five orders of magnitude less than for other materials frequently used as caps and barriers such as clay, soil bentonite and cement bentonite slurries. Therefore, the dimensions of the barriers can be reduced significantly.

Sources: TMS; Tech ID: 565

Notes/ Other Info: This technology may be utilized to stabilize waste forms during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Dry Barrier Applications for Landfills

Tech #: 140

Ref ID: 605

Date Available:		Physical Barriers-Waste Forms	
Past Investment($K):	0	Future Investment($K):	0

SCFA

Description: This technology developed an air-enhanced dry barrier for application to landfills in arid environments. For a landfill with a fine-grained cover, the downward seepage of water is intercepted by a layer of coarser material (gravel) where the moisture is evaporated and discharged before reaching buried waste.

Expected Capabilities: The objective of this project is to develop and demonstrate an air-enhanced dry barrier for application to landfills in arid environments. This technology is based on the well-founded capillary barrier concept: the contrast in unsaturated hydraulic conductivity of a coarse layer (barrier) and an overlying finer layer that limits downward water flow. The technique goes beyond the conventional capillary barrier because the coarse layer is dried with lateral air flow through the layer, preventing moisture accumulation in the layer and ensuring its unsaturated hydraulic conductivity remains low. The drying of the barrier by air can be accomplished by passive or active means, in order to ensure that the air flow is sufficient to load and transport any net recharge to the atmosphere. The dry barrier may also have application as a method for stripping gas-phase contaminants. The air-enhanced dry barrier could assume numerous forms and functions. Most simply, it can be a component of a cap or cover system. The barrier would principally be used to limit vertical infiltration through the cap. Another application would be in engineered liner systems. The air-dried layer can be used as a final barrier to prevent leachate movement beyond the landfill, and to strip denser-than-air gas-phase constituents (e.g., TCE) as they migrate downward. This application does not rely on an engineered liner, but rather utilizes the existing heterogeneous soil beneath most landfill sites. Air flow through a highly air-permeable layer beneath the landfill can be induced with vertical or directional holes to supply and remove air. These schemes may be able to utilize the prevailing westerly winds to induce sufficient air flow through the layer without relying on blowers or vacuum pumps. For applications underneath landfills, the contaminant concentration of the air is likely to be low enough as to not require treatment. This project will evaluate the feasibility of the dry barrier concept for applications at landfills in arid environments by a combination of laboratory, design, and field efforts. First, a better understanding of unsaturated transport properties of both engineered and natural soils is needed to develop the dry barrier concept. A novel technique will be evaluated as a means of simultaneously obtaining gas permeability and unsaturated hydraulic conductivity. Small-scale testing of the dry barrier concept will utilize sandbox experiments as two-dimensional models of dry barriers. These experiments will evaluate the ability of lateral air flow to remove downward flowing water using soil types with various properties. Based on the laboratory studies, dry barriers for field demonstration will be designed. At this point, the feasibility of different applications of dry barriers will be assessed. This project will culminate with field demonstration of the dry-barrier concept at a local site.

Sources: TMS; Tech ID: 605

Notes/ Other Info: This technology is designed for improved performance of barriers in landfills during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Permanent Isolation Barrier System

Tech #: 152	**Date Available:**	Physical Barriers-Waste Forms		
Ref ID: 869	**Past Investment($K):** 0	**Future Investment($K):** 0	**SCFA**	

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 869

Notes/ Other Info: There is no information entered in TMS, however the title suggests application to improved barriers during LTS.

Techn. Name: Bio-Engineering Capping Technology

Tech #: 163	**Date Available:**	Physical Barriers-Waste Forms		
Ref ID: 1288	**Past Investment($K):** 0	**Future Investment($K):** 0	**SCFA**	

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 1288

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to improved capping during LTS.

Techn. Name: In Situ Microbial Metal Immobilization

Tech #: 168 | **Date Available:** | Physical Barriers-Waste Forms

Ref ID: 1654 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 1654

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to containment during LTS.

Techn. Name: Biopolymer Based Selective Barrier for the Containment of Groundwater Contaminants

Tech #: 169 | **Date Available:** | Physical Barriers-Waste Forms

Ref ID: 1681 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: This project was a Small Business Innovative Research (SBIR) project in 1995.

Expected Capabilities:

Sources: TMS; Tech ID: 1681

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to containment during LTS.

Techn. Name: In Situ Stabilization and Retrieval System

Tech #: 171	**Date Available:**	9/30/1997	Physical Barriers-Waste Forms		
Ref ID: 1744	**Past Investment($K):**	5707	**Future Investment($K):**	0	**SCFA**

Description: This technology addresses the challenges presented by abandoned buried mixed-waste containment structures (which includes tanks, sumps, and vaults). It applies innovative grout and contamination control for in situ stabilization of contaminated buried wastes to mitigate contaminant release to the environment. Hot spot containment and then retrieval of hot spots in buried waste pits or trenches provide either a long-term or an interim solution.

Expected Capabilities: The in situ stabilization system uses innovative processes for injecting grout or other stabilizing materials into the waste form thereby stabilizing the contamination and mitigating environmental impacts due to leaching and contaminant migration. Depending on specific characteristics of the project, the waste can either remain as stabilized in place or exhumed with much less risk of exposure to the workers.

Sources: TMS; Tech ID: 1744

Notes/ Other Info: This technology may be utilized to contain wastes during LTS.

Techn. Name: Verification and Monitor System for Subsurface Barrier

Tech #: 175	**Date Available:**		Physical Barriers-Waste Forms		
Ref ID: 1773	**Past Investment($K):**	556	**Future Investment($K):**	0	**SCFA**

Description: Widespread use of subsurface barriers by DOE, other government agencies, and the private sector depend on the verification of the integrity of these structures after emplacement and during their anticipated lifetime. The integrated barrier verification system uses geophysical techniques to determine the barrier areal extent, field and laboratory geotechnical engineering methods to determine the barrier hydraulic performance, and gaseous tracer technology to determine barrier continuity and integrity.

Expected Capabilities: Widespread use of subsurface barriers by DOE and others requires the capability to verify their integrity after installation and monitor their performance during their anticipated lifetime. Although a number of technologies have been used to verify construction integrity and monitor long-term performance, no standardized method has been established. This verification and monitoring program intends to integrate several techniques into a standard package that would be accepted by regulators.

Sources: TMS; Tech ID: 1773

Notes/ Other Info: This technology may be utilized to sustain long term integrity of physical barriers during LTS.

Techn. Name: Close-Coupled Barrier

Tech #: 179

Ref ID: 1880

Date Available:

Past Investment($K): 1401

Physical Barriers-Waste Forms

Future Investment($K): 0

SCFA

Description: In the DOE Complex, subsurface infiltration of contaminants from over 3 million cubic meters of buried waste has produced over 200,000,000 cubic meters of contaminated soil and on the order of 600 billion gallons of contaminated ground water. To restrict movement of these contaminants DOE has adapted techniques proven for constructing horizontal subsurface barriers. Barriers are constructed by drilling on angles to the target depth beneath the site and injecting grout into the formation at pressures high enough to completely mix the grout and soil. The resulting overlapping soil-grout columns form barriers beneath waste sites. This method has broader application potential than other technologies that require low permeability anchor zones and/or homogeneous soils.

Expected Capabilities: The Close-Coupled Jet Grout Barrier places a relatively impermeable barrier beneath an existing waste site. The barrier has to be emplaced without disturbing the waste form. Jet grouting injects grout at high pressure and velocity. This action completely destroys the soil structure. The grout and the soil are intimately mixed, forming a homogeneous mass. Two grouting materials (cement and a high molecular weight polymer) are used to form the composite, or close-coupled barrier. The less expensive cement is used as the base for the more expensive polymer lining. This dual barrier system provides cost savings by using concrete and yet still has the superior physical attributes necessary to withstand nearly any waste form at the polymer lining. The anticipated benefits of installed barriers are that the waste volume will remain fixed, allowing additional time to develop remedial treatments.

Sources: TMS; Tech ID: 1880

Notes/ Other Info: This technology is applicable to improved barriers during LTS. Terminated, development completed through Gate 6.

Techn. Name: Sodium Silicate Flowable Grout

Tech #: 181 | **Date Available:** 9/30/1995 | Physical Barriers-Waste Forms

Ref ID: 1993 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: sodium silicate grout mixture is a type of injectable in-situ barrier material which has been adapted for conventional and innovative emplacement methods. Sodium silicate is naturally occurring and has been used in Europe.

Expected Capabilities:

Sources: TMS; Tech ID: 1993

Notes/ Other Info: This technology may be utilized as a physical barrier during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Montan Wax Flowable Grout

Tech #: 182 | **Date Available:** | Physical Barriers-Waste Forms

Ref ID: 1994 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: A montan wax mixture is a type of injectable in-situ barrier material which has been adapted for conventional and innovative emplacement methods. Montan wax is naturally occurring and has been successfully used in Europe.

Expected Capabilities:

Sources: TMS; Tech ID: 1994

Notes/ Other Info: This technology may be utilized as a physical barrier during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Cement Bentonite Thin Diaphragm Wall

Tech #: 184

Ref ID: 2060

Date Available:

Past Investment($K): 438

Physical Barriers-Waste Forms

Future Investment($K): 0

SCFA

Description: Cement bentonite thin diaphragm walls provide a barrier to migration of contaminants using jet injection of a cement-bentonite(clay)slurry into native soils. Barriers are made by injecting the slurry to form a continuous envelope in the soils beneath or around the contaminant source. The homogenized mixture of soil and slurry solidifies producing a low-permeability zone of minimal thickness. These barriers can be placed in a wide variety of geometries and geologic conditions because of the wide range of capabilities of the jet grout injection technology used in construction.

Expected Capabilities: The ongoing Cement Bentonite Thin Diaphragm Wall development at Dover Air Force Base was initiated in FY97. This project to develop a jetted wall technology has been a collaboration between the DOE, DoD, EPA, the university system, a foreign technology provider, and private industry. The industrial partners include Hayward Baker and DuPont. This technology is based on the transfer of a technology developed and used in Italy for hydraulic control. The thin diaphragm wall technology strives to capture and contain the contaminants such as DNAPLs before they reach and contaminate the aquifer below.

Sources: TMS; Tech ID: 2060

Notes/ Other Info: This technology may be utilized during LTS as a physical barrier. Terminated because lower priority than could be covered by available funding.

Techn. Name: **Permeable Reactive Treatment (PeRT) Wall for Rads and Metals**

Tech #: 48

Ref ID: 2155

Date Available:	9/30/2000	Physical Barriers-Waste Forms	
Past Investment($K):	2478	**Future Investment($K):**	0

SCFA

Description: This Accelerated Site Technology Deployment project will fund the design, installation and testing of a PeRT wall at the Montincello Mill Tailings Site (MMTS) in Monticello, Utah. As it is an UMTRA site, MMTS falls under the supervision of DOE´s Grand Junction Project Office (GJPO). The PeRT treatment wall contains a wall that is impermable to certain radioactive materials, while using a permeable ´gate´ to allow other materials to pass through. A PeRT wall is a zone of reactive material emplaced in the subsurface to treat and remediate contaminated groundwater that passes horizontally through it. The technology typically is deployed using a set of impermeable walls to funnel the groundwater into the permeable zone, or ´gate´, containing the reactive material. Iron particles are commonly used as the reactive material, depending on the type of contaminant and subsurface conditions. Impermeable walls are usually formed using a soil/bentonite clay slurry which extend down to bedrock. The reactive zone typically is formed with sheet piling, excavated, backfilled with reactive material, and the sheet piling is removed prior to operation. For more information on this and other ASTD projects, go to the ASTD home page at http://wastenot.inel.gov/tdi.

Expected Capabilities: A PeRT wall is a zone of reactive material emplaced in the subsurface to treat and remediate contaminated groundwater that passes horizontally through it. The technology typically is deployed using a set of impermeable walls to funnel the groundwater into the permeable zone, or ´gate´, containing the reactive material. Iron particles are commonly used as the reactive material, depending on the type of contaminant and subsurface conditions. Impermeable walls are usually formed using a soil/bentonite clay slurry which extend down to bedrock. The reactive zone typically is formed with sheet piling, excavated, backfilled with reactive material, and the sheet piling is removed prior to operation.

Sources: TMS; Tech ID: 2155

Notes/ Other Info: Identified by SCFA as a technology related to LTS. Terminated after Gate 6, awaiting decision for deployment.

Techn. Name: Iron Treatment Wall

Tech #: 185	**Date Available:**	9/30/1998	Physical Barriers-Waste Forms		
Ref ID: 2156	**Past Investment($K):**	1500	**Future Investment($K):**	0	**SCFA**

Description: This project constructs a passive, in situ, groundwater treatment system utilizing iron filings in lieu of pump and treat at the LLNL Site 300 to intercept TCE-laden groundwater, destroy the TCE, and control the migration of the TCE plume offsite.

Expected Capabilities: Zero-valent iron (iron filings) will be placed in a trench, where it will react with TCE in ground water and decompose the contaminant. Since the iron treatment trench will rely on the natural flow of ground water through it, this will form a passive treatment system planned to last twenty years or more. This system has the advantage of showing significant cost savings, and providing in situ treatment of TCE.

Sources: TMS; Tech ID: 2156

Notes/ Other Info: This technology may be utilized during LTS to control the spread of contamination.

Techn. Name: Long-Term Surface Barriers

Tech #: 188	**Date Available:**		Physical Barriers-Waste Forms		
Ref ID: 2186	**Past Investment($K):**	0	**Future Investment($K):**	0	**SCFA**

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 2186

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to containment during LTS.

Techn. Name: Subsurface Containment System

Tech #: 208	**Date Available:**	Physical Barriers-Waste Forms		
Ref ID: 3122	**Past Investment($K):** 0	**Future Investment($K):** 0	**SCFA**	

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 3122

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to providing containment of subsurface contaminants during LTS.

Techn. Name: Colloidal Borescope

Tech #: 114
Ref ID: 465

Date Available:	9/30/1999
Past Investment($K):	1044

Subsurface Science-Basic Understanding

Future Investment($K):	0

SCFA

Description: This is an innovative technology used to determine ground-water flow and direction through observation of the movement of colloidal particles suspended in water. Current applications include: site characterization by determining preferential flow paths and fractures; assessing heterogeneities associated with porous media; establishing the existence of immiscible contaminant layers and their associated flow properties; assessing the efficiency of ground-water remediation programs by determining the effective radius of influence of ground-water extraction systems; and evaluating the effects of sampling on colloidial concentrations. Potential applications include providing physical observation capabilities necessary to develop and confirm new, more accurate theoretical models of porous media flow process, and assessing the effect of water sampling techniques on natural colloidal concentrations.

Expected Capabilities: This instrument consists of a charge coupled device camera, an optical magnification lens, an illumination source, and a downhole compass in a watertight stainless steel housing. The borescope is lowered into boreholes to determine the direction of depth-discrete ground-water flow within the borehole. After calibration, the instrument is capable of yielding data that will provide the magnitude of the ground-water flow. The instrument is approximately 60 cm long, with a diameter of 43.4 cm. The electronic image is transmitted to the surface by a cable. The images are viewed on a high resolution monitor and recorded on VHS tape for further analysis. The magnified image corresonds to a 1.0 x 0.4 x 0.1 mm field of view. The flow of ground water in the borehole is quantified by observation of the movement of colloidial particles suspended in the water. Flow direction is determined by comparison with the downhole compass, and velocity by timing the movement of particles across the field of view.

Sources: TMS; Tech ID: 465

Notes/ Other Info: This technology may be used to monitor the transport of contaminants in the subsurface during LTS. Terminated after Gate 4 because lower priority than could be covered by available funding.

Techn. Name: High Resolution Imaging Using Holographic Impulse Radar Array

Tech #: 120 | **Date Available:** | Subsurface Science-Basic Understanding

Ref ID: 506 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: The objective is to develop and demonstrate a ground penetrating holographic radar system that will generate real-time, three-dimensional images of buried waste in low conductivity soils.

Expected Capabilities: The ground penetrating holographic radar (GPH) system consists of a 1-meter linear array of tapered slot antennae, a high-speed switching network, and relatively low-power impulse source operating over a large frequency bandwidth, approximately 2.5 to 7 GHz. The bistatic array system scans above the surface, gathers the subsurface target data, and processes the three-dimensional holographic images. Image length is continuous and is generated and displayed in real-time as the vehicle travels across the terrain with the array mounted perpendicular to the scan direction. The primary objective is to develop and demonstrate a field prototype and test a GPH radar system using an air-coupled linear array that will generate real-time, three-dimensional images of shallow buried waste in low conductivity soils.

Sources: TMS; Tech ID: 506

Notes/ Other Info: This technology may be utilized to produce images of subsurface LTS environments. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: Natural Isotopic Tracers of Radionuclide Transport

Tech #: 41 | **Date Available:** | Subsurface Science-Modeling

Ref ID: 3067 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description:

Expected Capabilities:

Sources: There was no data for this technology in TMS.

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Environmental Measurement While Drilling

Tech #: 6	**Date Available:**	9/30/1996	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 8	**Past Investment($K):**	1173	**Future Investment($K):**	0	**SCFA**

Description: The downhole sensors are located behind the drill bit and linked by a high-speed data transmission system to a computer at the surface. As drilling is conducted, real-time data are collected on the nature and extent of contamination, thus enabling on-the-spot decisions regarding drilling and sampling strategies. The system provides real-time data on environmental conditions, drill bit location, and system health.

Expected Capabilities: The Environmental Measurements-While-Drilling (EMWD) System represents an innovative blending of new and existing technologies to obtain real-time data during drilling. The long-term objective of this project is to distinguish contaminated from non-contaminated areas in real-time while drilling beneath a hazardous waste site. In EMWD, down-hole sensors are located behind the drill bit and are linked by a rapid data transmission system to a computer at the surface. Sandia developed WindowsTM-based software used for data display and storage. As drilling is conducted, real-time data are collected regarding the nature and extent of the subsurface contamination, enabling on-the-spot decisions about drilling and sampling strategies. Initially, the downhole sensor consisted of a simple gamma radiation detector, a Geiger-Mueller tube (GMT). The design includes data assurance techniques to improve safety by reducing the probability of giving a "false" safe indication where an unsafe condition actually exists. The EMWD System has been improved by the integration of a gamma ray spectrometer (GRS) in place of the GMT. The GRS consists of a sodium iodide-thallium activated crystal couples to a photomultiplier tube (PMT). The output of the PMT goes to a multichannel analyzer (MCA). The MCA data are transmitted to the surface via a signal conditioning and transmitter board similar to the used with the GMT. The system is currently compatible with fluid miser drill pipe, a directional drilling technique that use minimal drilling fluids and generates little or no secondary waste. Future work would adapt the radiological detection systems to other subsurface access equipment such as the cone penetrometer.

Sources: TMS, Tech ID: 8

Notes/ Other Info: The technology was developed for use during drilling, but could be used for sampling during LTS.

Techn. Name: SEAMIST

Tech #: 71 | **Date Available:** 9/30/1992 | Surveillance and Monitoring-Data Collection/Samp/Anal

Ref ID: 53 | **Past Investment($K):** 33 | **Future Investment($K):** 0 | **SCFA**

Description: SEAMIST has been demonstrated and deployed as an innovative tool to better access the subsurface for characterization and monitoring of contaminants in both vertical and horizontal boreholes, both above and below the water table. SEAMIST consists of an airtight membrane liner pneumatically and/or hydraulically emplaced inside a borehole, simultaneously maintaining the integrity of the borehole and permitting collection of contaminant samples from the subsurface at discrete depth intervals. Instrumentation can be used in horizontal, vertical, enlarged, constricted, and curved holes.

Expected Capabilities: SEAMIST has been demonstrated and deployed as an innovative tool to better access the subsurface for characterization and monitoring of contaminants in both vertical and horizontal boreholes. The technology has been developed by industry with assistance from DOE's Office of Technology Development to ensure it meets the needs of the environmental restoration market. SEAMIST consists of an airtight membrane liner pneumatically and/or hydraulically emplaced inside a borehole, simultaneously maintaining the integrity of the borehole and permitting collection of contaminant samples from the subsurface at discrete depth intervals; - is simple in concept and relatively inexpensive to use; yet, it provides quality samples of subsurface chemistry and hydrogeology; - lines the borehole temporarily or permanently, preventing the borehole from collapsing, limiting movement of air into the subsurface, and preventing fluid flow into and within the borehole (limits vertical mixing); - acts as a downhole support platform for sampling devices and instrumentation: sampling can be accomplished using sampling ports with attached tubes running back to the surface, using absorbent collectors, or in situ measurement devices; instrumentation can be towed through the borehole while making measurements (e.g. a neutron logging tool can be used to measure soil moisture content); can be used in horizontal, vertical, enlarged, constricted, and curved holes; has been demonstrated both above and below the water table; is emplaced into a borehole using a pneumatic pressure/canister system containing the membrane liner attached to a tether; the liner is installed by progressive eversion; positive
pressure is supplied to maintin the integrity of the borehole using either air, sand, water, or grout; can be retrieved by simply reversing the reel direction and maintaining constant pressure inside the canister; can be used for decontamination of ducting using stripcoat saturated duct liner materials and as a support platform for certain robotic applications; liner can be made of a wide variety of impermeable materials, including plastic tubular films and laminates; and has significant advantages over baseline technologies that it competes with in some instances and in other instances there is no known competitive technology. SEAMIST liners: cost less than $1000 for several-hundred-foot lengths; can be most cost-effective when requirements call for more than one characterization technology to be used within a single borehole; and can be greater than three times more cost-effective than conventional lysimeters when attempting to collect pore fluid samples from the unsaturated zone.

Sources: TMS; Tech ID: 53

Notes/ Other Info: This technology could be utlized during LTS to characterize and monitor stewardship areas. Terminated, development completed through Gate 6.

Techn. Name: ResonantSonic Drilling

Tech #: 72	**Date Available:**	9/30/1992	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 55	**Past Investment($K):**	1989	**Future Investment($K):**	0	**SCFA**

Description: ResonantSonic (TM) drilling is an innovative technique developed to access difficult soils such as cobbles and gravels to facilitate sampling and remediation. Sonic drilling is comprised of two major components: a drill rig with a sonic head and a drill pipe. The sonic drill head uses counter rotating weights to impart energy waves at a frequency up to 150 cycles per second which expand and contract the drill pipe creating a cutting action.

Expected Capabilities: The ResonantSonic (TM) drilling system uses a combination of mechanically generated vibrations and rotary power to efficiently penetrate the soil. The oscillator or drill head operates at frequencies close to the natural frequency of the steel drill column (up to 150 cycles per second) and consists of two counter-rotating rollers that generate sinusoidal wave forces. The vibration of the drill pipe, coupled with the weight of the drill pipe, and the downward thrust of the drill head, commonly result in rapid penetration. The ResonantSonic SM method uses no circulation media, and thus produces very little secondary waste. The ability to predict failures in the sonic system or drill string promises to reduce downtime and provide additional savings for environmental drilling throughout the DOE complex.

Sources: TMS; Tech ID: 55

Notes/ Other Info: This technology may be used to collect samples duirng LTS. Terminated, developed completed through Gate 6.

Techn. Name: Cryogenic Drilling

Tech #: 106	**Date Available:**	9/30/1995	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 155	**Past Investment($K):**	0	**Future Investment($K):**	0	**SCFA**

Description: This project is developing an innovative method of borehole drilling which employs conventional air drilling equipment that has been modified so that the flushing fluid is super-cold nitrogen. The cold gas flow freezes the moisture in the soil surrounding the hole and prevents collapse. Freezing has the advantage of preventing water or contaminants from entering the borehole and reaching the surface or other non- contaminated strata. The method may also allow a more accurate means of sampling subsurface solids and fluids. Application of the cryo-drilling method requires a special drill string and swivel. These components must be made from stainless steel or other alloy(s) that do not become brittle at low temperatures and must be fitted to the rig. The current experience is that these operations are neither expensive nor technically difficult. This method also requires that liquid nitrogen be provided during the drilling operations, together with the necessary transport and handling equipment. Contrary to popular belief, liquid nitrogen is no longer an exotic material; it is commercially available in tonnage quantities, and can be delivered to most sites by road tanker. The liquid costs between 5 and 10 cents per liter, and the project estimates that the nitrogen costs for drilling typical wells will be a few hundred dollars at most. The additional costs of these two special items are offset by the reduced time that is required to drill the well, principally because of the reduction in trouble time associated with borehole collapse. Moreover, in the case of the wells that were cryo-drilled at LBNL, it was impossible to drill one of the holes by conventional means. In addition, there are time savings resulting from not having to install or remove a casing to stabilize the borehole and from being able to drill a smaller diameter borehole due to the lack of a casing. In the long run, this technology will reduce the total effective project cost.

Expected Capabilities:

Sources: TMS; Tech ID: 155

Notes/ Other Info: This technology may be used to improve the quality of samples taken below the surface. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Tritium Analysis System

Tech #: 107 | **Date Available:** | Surveillance and Monitoring-Data Collection/Samp/Anal

Ref ID: 161 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: The Tritium Analysis System (TAS) has been developed for Savannah River Site to provide rapid field monitoring of existing plumes and to allow determination of hot spots in ground and surface waters. It is designed to be fully programmable for remote operation so that multi-site sampling, analysis, and data handling may be automated for unattended operations. The TAS incorporates a novel aqueous sampling device, a water purification system including commercially available ion exchange columns, and a modified Packard-based flow cell liquid scintillation counting (LSC) device. Communication between the field unit and the remotely-located control computer is achieved by modems.

Expected Capabilities:

Sources: TMS; Tech ID: 161

Notes/ Other Info: This technology may be applicable to LTS sampling and analysis. Terminated after Gate 5, tranferred to user to industry to complete.

Techn. Name: Multisorbent Sampler Aray

Tech #: 112 | **Date Available:** | Surveillance and Monitoring-Data Collection/Samp/Anal

Ref ID: 461 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: There is a need for subsurface sampling in the vadose zone for a broad range of VOCs at contaminated sites, either during site characterization or remediation. Conventional approaches to the acquisition of a soil gas sample at depths of more than a few feet involve the implantation of a tube, and withdrawal of a soil gas sample to the surface. The objective of the work is to develop, demonstrate, and deploy a novel sampling system for the multi-point collection of vadose zone soil gas samples.

Expected Capabilities: With the multi-point collection of vadose zone soil gas approach, samples are collected and concentrated at the point at which they emanate from the subsurface strata, not after having been transported through many 10's of feet of tubing. Combined with a sufficiently sensitive analytical system, the samples can be collected in small quantities so that the subsurface equilibrium is maintained.

Sources: TMS; Tech ID: 461

Notes/ Other Info: This technology may be applicable to sampling during LTS. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: Advanced In Situ Moisture Logging System

Tech #: 124

Ref ID: 533

Date Available:	9/30/1993
Past Investment($K):	553

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K):	0

SCFA

Description: A self-contained nuclear mositure/density probe for use in directionally drilled access tubing beneath waste sites is needed for the purpose of leak/contaminant detection and post-closure monitoring. The objective of this task is to demonstrate and evaluate a self-contained nuclear moisture/density probe in directionally drilled access tubing.

Expected Capabilities: The downhole in situ moisture logging system provides continuous data collection along the length of the access tubing allowing greater spatial coverage. With the advent of the horizontal/directional drilling technologies, the application of the downhole self-contained monitoring devices becomes significantly enhanced. In addition, information from downhole logging devices is essential in evaluating the performance of such remedial alternatives as capping or soil venting strategies, and as input to risk assessment modeling methodologies. In deep vadose zone regimes, this type of device/monitoring system might be used in lieu of an expensive monitoring well. The tool being evaluated will provide a self-contained neutron/gamma moisture/density probe for use in vertical or horizontal access tubing of almost any length. The tool can be used at practically any waste site throughout the DOE Complex where moisture content and/or soil density data are needed, whether for leak detection or for performance of a facility.

Sources: TMS; Tech ID: 533

Notes/ Other Info: This technology was designed for post-closure monitoring.

Techn. Name: Boresampler

Tech #: 142

Ref ID: 621

Date Available:		Surveillance and Monitoring-Data Collection/Samp/Anal	
Past Investment($K):	0	Future Investment($K):	0

SCFA

Description: The BoreSampler is designed to collect soil-gas and groundwater samples during well drilling. This technology provides an alternative to current methods, such as chemical analysis of retrieved sediment and water samples, or packer systems for soil-gas sampling and bailed groundwater samples.

Expected Capabilities: The focus of this task was to design and demonstrate a borehole soil-gas and aquifer sampling and testing device known as the BoreSampler. The BoreSampler has been demonstrated for soil-gas sampling during characterization activities for soil-vapor extraction remediation technologies. Technology transfer to EM-40 was completed in 1994. The BoreSampler obtains depth-discrete soil-gas and groundwater samples. It samples contaminant concentrations vertically without installing multiple wells. The device accesses the target zone between drilling runs by pounding or pushing a probe below the disturbed zone of drilling in order to collect the desired sample. The probe is removed after the sample has been collected. The BoreSampler is currently designed for use and demonstration with cable-tool drilling. Future improvements of the system may include incorporation with other drilling methods by wire-line and a drive head or driving rods. The prototype BoreSampler consists of a reinforced probe and intake protruding from the bottom of a larger carrier. The carrier holds a sample container. The carrier provides excess volume retention for groundwater sample purging and valves for excess air discharge. The Boresampler is designed to attach to drilling cable leading to the surface. For water sample collection, the device operates by driving the probe into undisturbed sediments below the bottom of a borehole. A sleeve covering the access holes is opened, allowing water to flow into the probe and through the system until the sample container is full. Before the container fills, excess water passes through the container and fills the carrier, purging the water that first enters the system. Water samples collected in the container and retrieved from the borehole are transferred to sample containers, and sent to a laboratory for analysis. A reinforced vacuum line leading to the surface is used for soil-gas sampling. A gas-flow orifice is placed in the probe, and the groundwater sample container is removed before deployment. The probe is driven into the sediments below the borehole and the sleeve is opened in the same manner as for water sampling. Gas-sampling apparatus (pump, flow meter, sample containers) are located at the surface to control and collect soil-gas from the unsaturated zone. The soil gas sample is withdrawn through the sample line. Soil gas concentrations are measured on site with field screening instruments. Samples are collected for laboratory analysis. Generated residuals which include soil gas are released to the atmosphere.

Sources: TMS; Tech ID: 621

Notes/ Other Info: This technology may be used during LTS to collect samples. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: Nucleic Acid Probes

Tech #: 149

Ref ID: 658

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Data Collection/Samp/Anal

Future Investment($K): 0

SCFA

Description: Rapid methods are needed to determine the performance of bioremediation processes, including natural/intrinsic attenuation. The baseline technology, the most probable number technique, depends on the ability of subsurface microorganisms to grow in culture. However, this technique can dramatically underestimate the amount of active microorganisms at a site. Many microorganisms (often times 90-99% of the total microorganisms) do not grow under laboratory conditions or are not physiologically active under the laboratory-imposed experimental conditions. Nucleic acd technology is performed on samples frozen immediately after they are obtained. Thus, the target microorganisms are detected at their environmentally relevant concentrations and physiological conditions, regardless of whether they will or will not grow under laboratory conditions. Nucleic acid technology can be utilized at many sites with contaminants for which the pertinent microbial degradative genes have been identified. More R&D is needed to extract and quantify RNA from environmental materials to reach the full potential of this technology.

Expected Capabilities: One of the ways to measure bioremediation performance is to show that nutrient addition causes the growth and/or increase in metabolic activity of microorganisms capable of degrading the contaminant of concern. The goal of this project was to demonstrate the use of DNA probes for monitoring the enzyme activity and microbial growth of certain microbial populations as nutrients were added during bioremediation activities. The DNA probe technology was compared to the baseline technology for monitoring population changes (the 'most probable number' technique) which involves taking soil samples, culturing the microorganisms in those samples, and counting the microorganisms that have grown in the culture.

Sources: TMS; Tech ID: 658

Notes/ Other Info: This technology may be utilized during LTS to monitor the effectiveness of cleanup activities. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Micropurging of Wells

Tech #: 173	**Date Available:**	9/30/1993	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 1762	**Past Investment($K):**	219	**Future Investment($K):**	0	**SCFA**

Description: For water well monitoring purposes, it is essential that sampling have a minimum interference with natural aquifer conditions. Water within the screened section of a monitor well flows through the casing at its normal ground water flow velocity. Therefore, a sample collected from within the screened section represents the aquifer formation water. The baseline sampling approach involves purging three well volumes at a low rate (< 0.5 liters/minute) such that only limited draw-down occurs and, consequently, mixing of the stagnant water above the screened interval with the formation water may take place. The Low Volume Micropurging method involves only purging (at a rate of < 1 gpm) the volume of water contained within the discharge lines and pump prior to measurement of field chemical parameters and sample collection.

Expected Capabilities: For water well monitoring purposes, it is essential that sampling have a minimum interference with natural aquifer conditions. Water within the screened section of a monitor well flows through the casing at its normal ground water flow velocity. Therefore, a sample collected from within the screened section represents the aquifer formation water. The baseline sampling approach involves purging three well volumes at a low rate (< 0.5 liters/minute) such that only limited draw-down occurs and, consequently, mixing of the stagnant water above the screened interval with the formation water may take place. The Low Volume Micropurging method involves only purging (at a rate of < 1 gpm) the volume of water contained within the discharge lines and pump prior to measurement of field chemical parameters and sample collection.

Sources: TMS; Tech ID: 1762

Notes/ Other Info: This technology may be applicable to water sampling during LTS. Terminated after Gate 3 because lower priority than could be covered by available funding

Techn. Name: Radon Mitigation and Monitoring

Tech #: 178

Ref ID: 1864

Date Available:		Surveillance and Monitoring-Data Collection/Samp/Anal	
Past Investment($K):	505	**Future Investment($K):**	0

SCFA

Description: Radon Mitigation and Monitoring systems remove radon from air and monitor the amount of radon in the air. There is a potential for high concentrations of radon to be released during waste retrieval and vitrification. This project will support developing, demonstratiing, testing, and applying innovative technologies at Fernald. Two subtasks will (1) develop and evaluate radon-removal methods using activated carbon at reduced temperatures (RUST Geotech), and (2) develop and evaluate the critical parameters of an oil-based radon removal system (ANL).

Expected Capabilities:

Sources: TMS; Tech ID: 1864

Notes/ Other Info: This technology may be applicable to air monitoring during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: In Situ Sampling of Trichloroethylene at Test Area North

Tech #: 197	**Date Available:**	9/30/1999	Surveillance and Monitoring-Data Collection/Samp/Anal		
Ref ID: 2930	**Past Investment($K):**	1043	**Future Investment($K):**	0	**SCFA**

Description: One of the greatest challenges in dealing with DNAPLs is locating them. In many cases, DNAPLs below the water table exist as thin ganglia and/or small droplets within the aquifer. In fratured rock aquifers, they can occur in specific fractures or fracture zones. Traditional DNAPL sampling techniques provide presence/absence and gross concentration indicators over a thick zone, but cannot target the exact amount and location of the DNAPLs. Remedial processes are most effective when focused on the precise amount and location of the DNAPL. INEEL has developed a sampler technology that can delineate the vertical profile of DNAPLs within the aquifer. This probe uses a permeable membrane to absorb volatile organic compounds and by deploying these membranes in a vertical sequence have defined the vertical DNAPL profile. This tool enables site owners to precisely define the concentration profiles and location of free phase DNAPLs (concentration above the solubility limit).

Expected Capabilities:

Sources: TMS; Tech ID; 2930

Notes/ Other Info: This technology may be applicable during LTS in locating and sampling subsurface contaminants and soils.

Techn. Name: Perfluorocarbon Tracers (PFTs)

Tech #: 189	**Date Available:**	9/30/2003	Surveillance and Monitoring-Engineered Units		
Ref ID: 2204	**Past Investment($K):**	467	**Future Investment($K):**	0	**SCFA**

Description: Perfluorocarbon tracers provide a reliable method to verify proper construction of subsurface barriers of all types. PFTs are an alternative tracer to the more commonly used SF6 gases. Both gases are injected inside the containment zone and monitored outside the barrier. The detection of gases outside the zone indicates a breach in construction and the location of gas leak may help define barrier imperfections so that they can be annealed. This technology is similar to SEAtrace but utilizes different gases (ref. Tech ID #308).

Expected Capabilities: Widespread use of subsurface barriers by DOE, other government agencies, and the private sector depend on the verification of the integrity of these structures after emplacement and during their anticipated lifetime. Use of PFT gaseous tracers shows promise as an excellent means of demonstrating barrier integrity. In a typical experiment, up to six PFTs are injected on one side of a barrier and monitoring ports, located on the other side of the barrier, are used to measure the release of the PFTs through the barrier. Testing has been conducted at three sites (Hanford, WA, Upton, NY, and Santa Fe, NM) on installed barriers and on barriers with known flaws. Evaluation of the data is being performed to determine the accuracy with which flaws can be detected. Comparisons are being made with data collected in experiments using an alternate gas tracer (Sulfur hexafluoride).

Sources: TMS; Tech ID: 2204

Notes/ Other Info: This technology is designed to monitor the integrity of containment barriers during LTS.

Techn. Name: Fracture Permeable Reactive Barrier

Tech #: 198

Ref ID: 2972

Date Available:	9/30/2001
Past Investment($K):	883

Surveillance and Monitoring-Engineered Units

Future Investment($K):	0

SCFA

Description: Efforts to contain or remove dissolved volatile organic compounds (VOCs) from Paducah Gaseous Diffusion Plant´s contaminated groundwaters to date have been through application of pump and treat (P&T) technologies. Since the solubility of and acceptable concentrations for these constituents in water are low, and the residual concentrations are still high, these VOCs will continue to contaminate groundwater for hundreds of years. This requires a long-term commitment of high operation and maintenance costs for P&T before the problem is eliminated. This project will deploy a vertical fracture permeable reactive barrier for the reductive dechlorination of TCE and absorption of Tc-99. The in situ treatment of the TCE groundwater contaminantion will be deployed to evaluate the long-term affects on subsurface contamination treatment. The use of alternative implementation of strategies to install this technology will be used for the first time on a U.S. Department of Energy site.

Expected Capabilities: Hydraulic fracturing field experiments in unconsolidated sediments have demonstrated, that a) vertical fractures can be placed at any required azimuth or bearing, and b)by injection in multiple wellheads, continuous coalesced fractures are formed. The technology involves initiating the fracture at the correct orientation and depth, by controlled injection a continuous reactive barrier is created. The hydraulic fracture reactive permeable barrier is constructed by injection through multiple wellheads spaced along the barrier alignment. A special downhole tool is inserted into each well and a controlled vertical slot is cut from which to initiate the subsequent fracture at the azimuth, orientation and depth desired. Prior to initiation of the controlled fracture, the slot tool is withdrawn and a packer is set into the well for pressure control. Multiple wellheads are then injected with the reactive mixture to form a continuous permeable reactive barrier.

Sources: TMS; Tech ID: 2972

Notes/ Other Info: This technology is intended to improve the long-term quality of containment during LTS.

Techn. Name: Long Term Cover System Functional Performance Assessment for Humid Climates

Tech #: 204	**Date Available:**	9/30/2001	Surveillance and Monitoring-Engineered Units		
Ref ID: 3051	**Past Investment($K):**	410	**Future Investment($K):**	300	**SCFA**

Description: Source term containment performance is a critical element in determining an appropriate risk mitigation measure for vadose zone remedial activities; critical performance issues are system longevity and interaction/evolution with the surrounding environmental setting. The challenges presented by humid climate performance monitoring is the close proximity of water tables,consistent high rainfall events, and a high rate of vegetative succession. These challenges provide a near-term opportunity to develop a functional performance monitoring scheme. The containment system´s assimilation into the surrounding ecological setting is a leading performance indicator of remedial effectiveness (Inyang, 1995). Based on the need to provide long-term source term containment performance verification, the goal of this task is to provide an integrated monitoring scheme that incorporates the ability to assess cover system long-term functional performance parameters and provide credible results.

Expected Capabilities:

Sources: TMS; Tech ID: 3051

Notes/ Other Info: This technology monitors the performance of barriers and covers during LTS.

Techn. Name: **Risked Based Performance Assessment of Long Term Cover Design for Waste Isolation and Disposal of DOE Facilities**

Tech #: 205

Ref ID: 3053

Date Available:	5/1/2001	Surveillance and Monitoring-Engineered Units		
Past Investment($K):	521	**Future Investment($K):**	0	**SCFA**

Description: Long-term cover systems are needed at DOE complexes to assist in isolating contaminants and waste that have migrated into the subsurface near landfills, waste disposal sites, and high-level waste tanks. To meet the long-term needs of designers, regulators, and involved stakeholders, a probabilistic, risk-based approach must be integrated into the design, modeling, and selection of long-term covers, considering regulatory requirements, environmental settings, site-specific features, events, and processes, engineering design parameters, and long-term verification and monitoring requirements. The result of this approach should yeild affordable and regulatory-acceptable design alternatives for long-term covers.

Expected Capabilities: Developing an integrated approach for probabilistic, risk-based performance assessment (PA) of long-term cover systems is the objective. The approach consists of two primary tasks: (a) development and implementation of an integrated total-system PA model and (b) development and implementation of sub-system process models (e.g., infiltration, percolation, contaminant transport, etc.). The first task develops the framework which integrates PA with engineering activities to assess and evaluate alternative cover designs based on probabilistic, risk-based calculations that address uncertainties within the system. The evaluation of the impacts of these uncertainties on risk or regulatory compliance will provide the foundation for choosing a cost-effective design approach while allowing the site owner to prioritize the value of additional monitoring and site characterization efforts. The second task produces the sub-system models that are used by the integrated PA model. Site-specific processes that influence long-term performance are included in the sub-system models, which will be implemented and combined to provide the basis for the integrated PA model. A third task includes non-technical administrative tasks that focus on selecting and applying site-specific performance assessment analyses to develop a general framework and tool that can be used for other DOE complexes.

Sources: TMS; Tech ID: 3053

Notes/ Other Info: This technology provides the process to select credible covers during LTS.

Techn. Name: Characterizion of the Environmental Envelope for the design of Long term Cover

Tech #: 207	**Date Available:**	9/30/2001	Surveillance and Monitoring-Engineered Units		
Ref ID: 3054	**Past Investment($K):**	171	**Future Investment($K):**	255	**SCFA**

Description: Although engineered covers are planned for almost all on-site stabilization applications within the DOE complex (closure of landfills, waste sites, and high-level waste tanks), there is no standard approach for designing covers intended to last 100s of years. The Environmental Envelope component is a development guidance for projecting reasonable ranges of long-term change in environmental parameters needed as input to the other components: performance assessment, engineering and monitoring of engineered covers. Methods and protocols will be developed to address characterization of physical and biological properties of earthen and plant materials needed for engineering and vegetation management, evaluation of site-specific ecosystem processes and paramters needed for input to performance assessment and monitoring, and evaluation of natural analogs of possible future long-term change in environmental parameters.

Expected Capabilities: Characterization of the environmental envelope will provide the climate, soils, geomorphology, hydrogeology, plant ecology, and animal habitat data required for performance assessment, engineering, and monitoring. The decision matrix, methods, and protocols are under development to characterize near-term ecosystem dynamics and to project a reasonable range of long-term changes in the environmental setting (climate, ecology, and soils).

Sources: TMS; Tech ID: 3054

Notes/ Other Info: This technology is applicable to the long term monitoring of covers and barriers during LTS. Terminated, awaiting decision for deployment.

Techn. Name: In Situ Permeable Flow Sensor

Tech #: 77	**Date Available:**	9/30/1995	Surveillance and Monitoring-Instruments/Sensors/Devices	
Ref ID: 99	**Past Investment($K):**	2528	**Future Investment($K):** 0	**SCFA**

Description: The In Situ Permeable Flow Sensor uses a thin cylinder heater buried in the ground to directly measure the direction and magnitude of 3-D groundwater flow in porous aquifers. Temperature distribution on the cylinder surface varies as a function of groundwater flow magnitude and direction. Previous technologies were labor intensive and required that large volumes of contaminated water be pumped to the surface for storage and disposal.

Expected Capabilities: Groundwater and soil gas flow sensors are a new technology for measuring directly the full 3-dimensional fluid flow velocity vector at essentially a single point in porous media. Each probe consists of a rod approximately 30 inches long by 2 inches in diameter, fabricated of low thermal conductivity polyurethane foam. Deployed on the surface of the rod are a thin-film, flex circuit style heater and an array of 30 temperature sensors (thermistors). The probe is buried in the ground at the point where the flow is to be monitored. When the heater is activated, a temporally and spatially uniform heat flux from the probe is established. In the absence of any flow past the probe, the temperature distribution observed on the surface of the probe is independent of azimuthal position of the probe and symmetric about the vertical midpoint of the probe. If there is significant groundwater flow past the instrument, then the temperature distribution on the surface of the tool is perturbed as some of the heat emanating from the probe is advected around the tool by the moving fluid. The downstream side of the probe will be relatively warm compared to the upstream side. The direction and magnitude of the full 3-dimensional flow velocity vector can be deduced from the measured temperature distribution on the surface of the probe. In water-saturated sediments the probes are capable of accurately measuring ground-water flow velocities in the range of approximately 5 x 10 -6 to 5 x 10 - 3 cm/s. Because the heat capacity of a given volume of air is much less than that of the same volume of water, the probes can measure air flow velocity in dry sediments in the range of 1 x 10 -3 to 1 cm/s. Changes in flow about one order of magnitude smaller than this can be resolved. A critical aspect of obtaining reliable data from the flow sensors is the method of deployment. In order to avoid negative impacts on the flow velocity caused by the presence of a borehole, well screen, and gravel pack, the flow sensors must be buried directly in the ground, in intimate contact with the formation. This limits the range of applicability of the technology to sites where the sediments are unconsolidated. The probe is installed in a borehole at the desired monitoring location. The borehole can either be backfilled with appropriate media, or soil can be allowed to collapse around the probe. Although this deployment strategy means that the relatively inexpensive probes cannot be recovered once deployed, they can be monitored remotely on a continuous basis for long periods of time (months to years).

Sources: TMS; Tech ID: 99

Notes/ Other Info: This technology may be utilized for monitoring and sensing groundwater flow. Terminated after Gate 5, transferred to user or industry to complete.

Techn. Name: HaloSnif

Tech #: 78

Ref ID: 103

Date Available:	9/30/1993
Past Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	0

SCFA

Description: HaloSnif was designed to monitor carbon tetrachloride vapor in the vadose zone at the Hanford Site. However, it can measure any volatile chlorinated compound in air, gas, or water. Halosnif was evaluated at Hanford as a real-time monitoring system for measuring carbon tetrachloride concentrations in soil gas extracted at the vapor extraction site. Targeted toward environmental cleanup, HaloSnif was developed as a monitoring system to provide real-time concentration data for volatile chlorinated hydrocarbons. One specific application demonstrated interfacing HaloSnif to a cone penetrometer rig to give profiles of carbon tetrachloride concentrations as a function of depth. A second application at Hanford included using HaloSnif as a real-time monitor for carbon tetrachloride concentrations in soil gas extracted and subsequently cleaned up. HaloSnif has also been used to monitor real-time concentrations of trichloroethylene, tetrachloroethylene, and carbon tetrachloride in water samples. With this most recent development, HaloSnif may be useful for process or facility monitoring at DOE or industrial sites. During monitoring operation, HaloSnif operates at sub-ambient pressure (40torr). It continuously draws an air sample through a critical orifice into the plasma excitation chamber where it is mixed with helium and excited with a radio-frequency signal. The plasma chamber is coupled via a fused silica optical fiber to the signal processor unit. The optical emission of the plasma is filtered with a narrow band pass filter designed to monitor the 837.6nm emission line from the excited chlorine atom. The intensity of the chlorine emission is directly proportional to the concentration of chlorine containing species in the sample gas. The detection sensitivity for carbon tetrachloride is 5ppmv. The response of the system is linear from the detection limit to 10,000ppmv. The detection limit for other chlorine containing compounds can be estimated by determining the ratio of chlorine in the compound of interest to that of carbon tetrachloride. Data acquisition is achieved using the LabView[TM] data acquisition software package installed on a Macintosh computer system. The data acquisition system is interfaced to the electro-optical signal processing module via a 1 to 10 volt analog output. Real-time concentrations of total chlorinated compounds are displayed on the monitor for observation by on-site personnel. All data is stored in computer memory for post-run processing and analysis.

Expected Capabilities:

Sources: TMS; Tech ID: 103

Notes/ Other Info: This technology may be utilized for monitoring vapor in the vadose zone. Terminated, development completed through Gate 6.

Techn. Name: Very Early-Time Electromagnetic System

Tech #: 105 | **Date Available:** 11/15/1998 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 154 | **Past Investment($K):** 775 | **Future Investment($K):** 0 | **SCFA**

Description: The Very Early Time Electromagnetic (VETEM) system is a time-domain system designed to image the shallow (0- approx. 5 m) subsurface of the earth for waste pit delineation and characterization and other contamination and buried object applications. Related technologies include ground-penetrating radar (GPR) and time-domain electromagnetic (TDEM) systems. VETEM is intended to fill the gap between GPR and TDEM by providing deeper penetration than GPR in conductive earth, and better resolution than conventional TDEM.

Expected Capabilities:

Sources: TMS; Tech ID: 154

Notes/ Other Info: This technology may be used to map and characterize the shallow subsurface. Terminated after Gate 4 because lower priority than could be covered by available funding.

Techn. Name: Landfill Assessment and Monitoring System

Tech #: 109	**Date Available:**		Surveillance and Monitoring-Instruments/Sensors/Devices	
Ref ID: 170	**Past Investment($K):**	0	**Future Investment($K):** 0	**SCFA**

Description: The Landfill Assessment and Monitoring System (LAMS) is a method to characterize metal and mixed waste contaminants, their sources, and their migration beneath landfills. The LAMS emphasizes minimally-intrusive technologies and downhole sensors, utilizing the best available and emerging technologies with the minimal developmental requirements. The LAMS consist of five separate subsystems: screening and sampling optimization techniques, innovative drilling technologies, onsite analysis and in situ sensors, subsurface monitoring technologies, and data evaluation and risk analysis techniques. LAMS utilizes compatible and complementary technologies.

Expected Capabilities: The LAMS is a method to assess hazardous and mixed-waste contaminants, sources, and their migration beneath landfills. The steps involved in this method are illustrated in. The emphasis of the system is on minimally intrusive technologies and downhole sensors, when possible. The system focuses on using the best of available and emerging technologies, with minimal development work. The LAMS is envisioned to be a start-to-finish system for landfill assessment, using compatible, complementary, and integrated technologies. The result is a savings in cost and time. The LAMS consists of five separate subsystems: (1) screening and sampling- optimization techniques, (2) innovative drilling technologies, (3) on-site analysis and in situ sensors, (4) subsurface monitoring technologies, and (5) data evaluation and risk-analysis techniques. In some instances, technologies may be combined to produce hybrid systems, such as directional boring and downhole sensing. The LAMS approach employs minimal or nonintrusive assessment, safer directionally drilled access, measurement while drilling, sample optimization strategy, membrane liners, in situ sensors, and on-site analyses. An additional emphasis of the LAMS is on long-term monitoring, as this aspect of remediation and containment has become more important. Monitoring of active, in situ remedial actions, as well as post-closure and containment effectiveness, is being pursued. These activities include a Verification and Monitoring Options Study to evaluate research options needed in this area. In addition, field studies to monitor in situ chromium reduction, electrokinetic removal of chromium in unsaturated soils, subsurface barrier performance, and integrity of landfill caps and covers are also being conducted. When individual technologies are used in conjunction with each other as a system, several advantages result. These include savings in time and cost. Also, a focus on minimally intrusive and in situ techniques reduces the risk of worker exposure to wastes or contaminated media. The LAMS provides better resolution of site characteristics, contamination sources, vertical and aerial extent of contaminant plumes, and monitoring of remedial and post-closure actions. Primary goals of the LAMS are rapid transfer and commercialization of these technologies throughout the DOE complex and the private sector.

Sources: TMS; Tech ID: 170

Notes/ Other Info: This technology may be applicable to characterizing and monitoring contaminant flow during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Fiber Optic Probe for Trichloroethlylene in Soil and Groundwater

Tech #: 115	**Date Available:**	9/30/1992	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 466	**Past Investment($K):**	1415	**Future Investment($K):**	0	**SCFA**

Description: Site characterization is required where trichloroethylene (TCE) has been discharged into the soil and groundwater. Contaminated samples are collected and analyzed by an outside laboratory. This is an expensive and time consuming consuming process. An alternative is to use a fiber optic probe that can be put down monitoring or vadose zone wells or punched into the soil using a penetrometer type device. This allows measurements to be made continuously and at relatively low cost. In situ measurements can also be made at ambient temperatures using this method. This probe is selective for TCE, and can detect this compound at levels below the Environmental Protection Agency (EPA) ground-water standards.

Expected Capabilities: The fiber optic probe is used to monitor in situ contaminant levels in soils. The probe can be placed in a cone penetrometer or isolated via packers in discretely screened intervals in monitoring wells. The system was successfully demonstrated and licensed to industry for monitoring use and other applications. The principle of detection for the probe is a quantitative chemical reaction that forms visible light absorbing products on exposure to TCE. Absorption of light relative to reaction time is directly related to contaminant concentration. The measurement system has three major components: a pumping system, an electro-optic instrument (that provides filtered light to the probe and detects the returning transmission light), and the probe.

Sources: TMS; Tech ID: 466

Notes/ Other Info: This technology may be utilized to monitor contaminant levels in the subsurface during LTS. Terminated, development completed through Gate 6.

Techn. Name: **Biomolecular Probe Analysis: Bioremediation Organisms**

Tech #: 116

Ref ID: 468

Date Available:	9/30/1995
Past Investment($K):	0
Future Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

SCFA

Description: The goal of this project was to demonstrate the use of deoxyribonucleic acid (DNA) probes for monitoring the enzyme activitiy and microbial growth of certain microbial populations as nutrients were added during bioremediation activities.

Expected Capabilities: The DNA probe technology was compared to the baseline technology for monitoring population changes (the 'most probable number' technique) which involves taking soil samples, culturing the microorganisms in those samples, and counting the microorganisms that have grown in the culture. Using DNA probes to measure population and activity levels involves utilizing a technique called nucleic acid hybridization. This technique involves three steps. First, nucleic acids (either DNA or ribonucleic acid [RNA]) are chemically extracted from the microbial community present in the environmental sample. Second, specific nucleic acid sequences corresponding to a gene of interest (e.g., the ability to degrade trichloroethylene [TCE]) are produced and labeled with a highly sensitive chemical signal. Third, the labeled nucleic acid sequence (i.e., the probes) is applied to the nucleic acids extracted from the environmental sample under conditions that allow the probe to find and bind to identical and highly similar sequences in the environmental sample. After the unbound probe is removed, the resulting signal is measured to identify the presence and relative abundance of microorganisms that are degrading (for RNA) or have the potential to degrade (for DNA) the contaminant of interest. An increase in the intensity of the signal or an increase in the frequency of a positive signal is used to monitor the perfomance of the
bioremediation process.

Sources: TMS; Tech ID: 468

Notes/ Other Info: This technology may be used to monitor microbial growth during LTS. Terminated, unacceptable cost or schedule.

Techn. Name: Inverse Scattering Ground Penetrating Radar Imaging of Buried Objects

Tech #: 118

Ref ID: 499

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

SCFA

Description: The primary objective of the Inverse Scattering Ground Penetrating Radar Imaging of Buried Objects technology is to demonstrate imaging of buried objects in Idaho National Engineering Laboratory soil with the three-dimensional scanner developed by TechniScan, Inc.

Expected Capabilities: The three-dimensional scanner, which was developed by TechniScan with funding through Landfill Stabilization Focus Area (LSFA), is an inverse scattering ground penetrating radar (GPR) system. It produced quantitative, distortionless images analogous to a computer automated tomography (CAT) system. It is intended to generate images of buried waste objects in INEL soil. The unique advantages of the Inverse Scattering Ground Penetrating Radar Imaging of Buried Objects technology compared to more conventional approaches for characterization of buried waste are its high spacial resolution, self-focusing properties, reverberation free images, and quantitative images of dielectric properties.

Sources: TMS; Tech ID: 499

Notes/ Other Info: This technology may be used for mapping subsurface objects during LTS.

Techn. Name: Rapid Transuranic Monitoring Laboratory

Tech #: 122	**Date Available:**	9/30/1993	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 515	**Past Investment($K):**	1918	**Future Investment($K):**	0	**SCFA**

Description: The Rapid Transuranic Monitoring Laboratory is intended to monitor airborne and soil transuranic isotopes in a cost-effective manner. The laboratory can quickly evaluate release situations to allow rapid remedial actions to be taken. The monitoring laboratory can process over 100 samples per day of soils, filters, and smears in a field setting.

Expected Capabilities: The Rapid Transuranic Monitoring Laboratory (RTML) is contained in two trailers, which are 8' x 24' and 8' x 48' in size. The smaller trailer houses a sample preparation laboratory. The larger trailer contains (a) one terminal that controls and displays spectral data from four alpha continuous air monitors (CAMs), (b) two Ordela large-area ionization chamber alpha spectrometers, (c) one thin-window gamma ray spectrometer and automatic sample changer, (d) one VAX 4000 Model 100 computer, and (e) computer terminals and two printers used to display and generate reports of analysis results. The unit can process over 100 samples per day of soils, filters, and smears in a field setting. The lower levels of detection vary depending on the analysis system. The large area alpha ionization spectrometer can process 33 soil samples per day at 20 pCi/g (alpha). The U-L-Shell x-ray system can process 79 samples per day at 50 pCi/g (alpha) and 1-5 pCi/g (gamma). Simultaneously, the alpha CAMs can analyze air quality continuously at 1 DAC-hr. The primary objective is to develop a field deployable RTML that can continuously monitor airborne transuranic (TRU) concentration and rapidly analyze soil, smear, and air filter samples for TRU isotopes, and fission and activation products in a cost-effective manner.

Sources: TMS; Tech ID: 515

Notes/ Other Info: This technology may be utilized to monitor TRU isotopes in the ground during LTS. Terminated, development completed through Gate 6.

Techn. Name: Real Time Monitoring of Transuranic Contaminated Dust

Tech #: 125 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 536 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: A real-time dust monitor (RTDM) will detect TRU-contaminated dust based on laser-induced breakdown spectroscopy (LIBS) technology. The RTDM will be correlated with an alpha continuous air monitor (CAM) system. An instrument will ultimately be developed for deployment to the field environment. The primary objective is to develop and demonstrate a real-time, in situ instrument based on optical techniques for monitoring transuranic (TRU) contaminated dust. Incorporating alpha CAMs into the system to provide an improved radioactive assay capability for buried waste remediation sites is included in the objective. However, the LIBS technology may allow stand-alone analysis for the airborne TRU contaminants.

Expected Capabilities:

Sources: TMS; Tech ID: 536

Notes/ Other Info: This technology may be used for TRU monitoring during LTS. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: Cross Borehole Electromagnetic Imaging

Tech #: 127 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 547 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: In landfills containing metallic waste forms, the contrasts in electrical properties enhance the effectiveness of several electrical and electromagnetic methods. For the problem of source and plume detection at these landfill sites, the continuous wave and pulsed radar systems image the subsurface for targets that may be uniquely suited for the method.

Expected Capabilities: Electrical properties such as resistivity, determined by electromagnetic methods, are unique among geophysical measurements, since the electrical property is directly related to chemical composition of the fluid passing through the geologic medium. Fiber-optic cables lower the tool, which is 2' in diameter and 6-12' in length, into boreholes to determine properties such as permeability, saturation, and water chemistry. Based on the attenuation and phase shift of radio frequency signals propagated between boreholes, mapping of electrical conductivity or permittivity between boreholes can be accomplished.

Sources: TMS; Tech ID: 547

Notes/ Other Info: This technology may be applicable to mapping of waste sites during LTS. Terminated, development completed through Gate 6.

Techn. Name: Magnetometer Towed Array

Tech #: 128 | **Date Available:** 9/30/1993 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 548 | **Past Investment($K):** 120 | **Future Investment($K):** 0 | **SCFA**

Description: A Surface Towed Ordnance Locator System has been developed that can provide rapid and repeatable surveying of the subsurface for landfill characterization. The system can provide the location and quantities of subsurface targets. The survey system should enhance the speed and thoroughness of environmental cleanup.

Expected Capabilities: The magnetometer towed array, also called Surface Towed Ordnance Locator System (STOLS[TM])was built by the U.S. Navy as a proof-of-principal, non-intrusive characterization system to locate and identify buried ordnance. SNL, in conjunction with the U.S. Naval Research Laboratory and GEO-CENTERS, has adapted the system for use in landfill characterization. Current technology is based on walkover magnetometer surveys that provide low-resolution data at the rate of an acre or two per day. STOLS[TM] has been commercialized by GEO-CENTERS, Inc. This vehicle-based system deploys a non-intrusive sensor platform containing seven total-field magnetometers with precise satellite positioning for locating the magnetic data. The acquired data sets are processed to produce high-resolution magnetic maps of the surveyed area (on the order of 0.5-meter resolution). The vehicle that tows the sensor platform is rugged for handling the terrain variations in diverse field conditions. It enables the system to rapidly cover the survey area at a rate of at least 15 acres per day. The vehicle has been designed to exhibit a low magnetic signature in order to minimize interference with the magnetometers. In addition, the sensor platform, itself composed of low-magnetic materials, has been designed to keep the sensors at a sufficient distance from any spurious magnetic sources. An on-board computer accepts directional information from an electronic compass, and position coordinate information is now updated once per second by the dynamic global positioning system. The on-board computer also provides real-time information to the driver. The sensor platform contains the array of 7 cesium-vapor magnetometers spaced at 0.5 meter intervals perpendicular to the direction of travel. Each of these magnetometers measures the total field strength at a rate of 20 points per second. This rate yields a total data-point density of 100,000 data points per acre. The field strength at anypoint is determined by the sum of the Earth's field plus any local variations caused by the presence of ferrous materials. Data from a nearby reference station is used to remove the effects of the Earth's field from the sensor platform data. This step leaves behind only the variations due to local ferrous objects. Precise positioning data is acquired simultaneously with the magnetic data. Based on a global positioning system, the location of the sensors is calculated at every instant to provide positions for every magnetic data point. After interpolating the positioned magnetic data to a regularly-spaced grid, magnetic maps of the survey area are readily produced and are repeatable from survey to survey. On these maps, the magnetic variations due to local
ferrous objects are readily located through the use of appropriate color scales. In addition, areas that the system has yet to survey are clearly seen, and can be subsequently located and surveyed. Local landmarks and locations significant to a given survey can also be indicated. Displayed on a video monitor, the magnetic map of a surveyed area provides the user interface to the semi-automated target analysis for small isolated targets. Using a mouse, the user selects an anomaly due to a given ferrous target. The target analysis then performs an iterative least-squares model match to determine the best fit of magnetic moment and depth to the selected anomaly for small isolated targets. Detection ranges include small pieces of ordnance (containing a few pounds of iron) down to a maximum depth of 6.5 meters.

Sources: TMS; Tech ID: 548

Notes/ Other Info: This technology may be utilized during LTS to characterize a site. Terminated, development completed through Gate 6.

Techn. Name: Field Screening Laboratory System

Tech #: 129

Ref ID: 552

Date Available:	9/30/1995
Past Investment($K):	0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	0

SCFA

Description: The objective of the Field Screening Laboratory is to develop a mobile field screening laboratory capable of high-quality, same-day metals and organic analyses of toxic, radioactive, or mixed waste environmental samples.

Expected Capabilities: The Field Screening Laboratory intends to rapidly develop new methods by enhancing and more fully utilizing the capabilities of commercially available analytical instruments. These instruments include an X-ray fluoresence (XRF) spectrometer for metals analyses of soil/sediment samples and a gas chromatograph with a mass spectrometer (GC-MS) for volatile organic analyses of water and soil samples. XRF is a bulk characterization technique for the rapid, simultaneous, and non-destructive detection of all elements heavier than fluorine for soil and sediment environmental samples. A soil/sediment sample is collected, dried, and sifted through a 10-mesh screen in preparation for metals analysis by the XRF. The sample is, then irradiated with x-rays. The x-rays are re-emitted and are characteristic of its composition which includes the detection of metals contaminants. If any chrome is found, it is ground to 200-mesh and another analysis is conducted. Efforts are now being made to use thin films of ground powdered samples, which reduces the mass of the sample without reducing sensitivity. The GC-MS is used for volatile organic analysis by collecting gas extracted from the sample. A small aliquot is carried into the gas chromatograph for analysis, resulting in a chromatograph. The mass spectrometer reads the chromatograph and identifies organic contaminants.

Sources: TMS; Tech ID: 552

Notes/ Other Info: This technology may be utilized during LTS for bulk characterization. Terminated after Gate 6, awaiting decision for deployment.

Techn. Name: Absorptive Stripping Voltammetry

Tech #: 133
Ref ID: 582

Date Available: 9/30/1992
Past Investment($K): 0
Future Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

SCFA

Description: Absorptive Stripping Voltammetry (ASV) analysis is well suited for field screening. The system is compact, requiring minimal electricity (10 amp. at 120 volts AC), and producing high quality data in a short period of time. In fact, for trace metals, ASV is an even more sensitive technique than lab analysis. Significant cost savings are anticipated using ASV to support characterization and remediation activities. The cost savings arise from the ability to screen sediment samples concurrent with sampling activities. In addition, field screening efforts during removal actions can help delineate when a cleanup level has been achieved for a contaminant of concern.

Expected Capabilities: The objective of this task is to develop and test the effectiveness of using ASV to determine the concentrations of leachable chromium, uranium, lead, cadmium, copper, and zinc on soils/sediments. The task will also identify underground source terms and plumes underlying chemical waste and mixed waste landfills. Rapid on-site analysis can significantly decrease stand-by time for cleanup personnel waiting for off-site laboratory results, thus increasing the cost effectiveness of site cleanup.

Sources: TMS; Tech ID: 582

Notes/ Other Info: This technology may be utilized during LTS to collect characterization data. Terminated, development completed through Gate 6.

Techn. Name: Cross-Well Seismic Imaging

Tech #: 135 | **Date Available:** 9/30/1992 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 588 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: Seismic imaging has proven effective and useful in oil and gas exploration and reservoir characterization. Seismic techniques are the established method for mapping the structural geology of the sites deep within the earth. Recent technological advances have made it possible to identify fluid-saturated regions. The objective of this task is to determine the applicability of high-frequency seismic crosswell imaging for characterizing, identifying, and locating contaminated subsurface sites, waste plumes, and local geologic structure and hydrology.

Expected Capabilities: The objective of this task is to determine the applicability of high frequency seismic crosswell imaging for characterization contaminated subsurface sites. The technology utilizes seismic sources (high-frequency piezoelectric) and receivers (accelerometers) clamped to the borehole walls. A high-voltage signal energizes the piezoelectric crystal and causes an acoustic signal to be transmitted through the earth, where it is picked up by the receiver. The time of flight of the signal and amplitude of the signal are measured, as well as the details of the effect and the propagation path. These signals are then processed for information on the mechanical properties of the earth. A primary goal is to demonstrate the frequency range, resolution, and sensitivity of borehole seismic methods in boreholes that cannot be filled with water (arid sites), or in which conventional clamping devices cannot be used for coupling the seismic sources and receivers to the borehole walls. An equally important goal is to demonstrate that high-resolution seismic imaging can be used to characterize structure and lithology related to transport properties in a routine and cost-effective manner. The scope of this project is to start with existing technology that uses piezoelectric transducers for transmitting and receiving high-frequency seismic energy in water-filled boreholes, and adapting this technology to boreholes which are often only partially filled with water or completely dry. In addition, boreholes in contaminated sites are generally lined with a relatively fragile material, so conventional clamping devices cannot be used. The approach is staged to first evaluate different mechanisms for borehole coupling, which will affect frequency content and amplitude of the seismic signals. If successful, the sources and clamping mechanisms will be improved to allow shear wave transmission in addition to compressional wave transmission. An equally important task is to demonstrate in-field collection and imaging methods, such that the imaging results can be obtained in an efficient and cost-effective fashion. The latter phases of the project will use this technology at an arid site that will be remediated. The last phase will be to transfer as much technology as possible to private industry.

Sources: TMS; Tech ID: 588

Notes/ Other Info: This technology may be utilized to map and charaterize waste sites during LTS. Terminated, development completed through Gate 6.

Techn. Name: Mobile Inductively Coupled Plasma Optical Emission Spectrometer

Tech #: 138

Ref ID: 602

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

SCFA

Description: Uranium, actinide and heavy metal contamination of soils is a widespread problem in the DOE Complex. Extremely sensitive instrumentation is required to detect contamination down to the levels of required remediation. In order to characterize this contamination over physically large areas of potential contamination, and to monitor the effectiveness of cleanup and decontamination efforts, a field analytical technique is needed that can give real-time measurements to direct cleanup efforts in a timely manner. The Mobile Inductively Coupled Plasma Optical Emission Spectrometer meets these needs by giving low cost, low detection limit analysis of soil samples in a few minutes per sample with a minimal risk of contamination and exposure.

Expected Capabilities: The focus of this project is to determine the feasibility of utilizing the Mobile Inductively Coupled Plasma Optical Emission Spectrometer technique for determining the existence and extent of radioactive elements in soil, especially uranium, thorium, and plutonium. The technology, used worldwide for the detection of over 70 elements, has been adapted for a mobile analytical facility. Field operable sampling and analysis systems have a great advantage in that samples, especially radioactive samples, need not be collected, catalogued, transported, and stored prior to analysis, providing significant savings in analytical costs. The focused output of a frequency doubled Nd:YAG laser (532 nm) is used to ablate unprepared or minimally prepared soil samples. The generated aerosol in entrained in an argon gas flow and introduced into an inductively coupled plasma. The plasma dissociates, atomizes, and ionized the aerosol. The ions may be quantitated by either measuring the intensity of characteristic light emissions (atomic emission spectroscopy), or by introduction of the ions into a quadruple mass spectrometer (MS). Both systems are widely used techniques for the determination of a large number of elemental constituents in environmental samples, particularly heavy metals and actinides. They may be used to analyze solids, liquids, and airborne aersols. The technique has been used for the analysis of metals, soils, glasses, ceramics, and powders. Additionally, it is particularly useful for the analysis of nonconducting materials or where sample preparation and handling is either undesirable or impossible.

Sources: TMS; Tech ID: 602

Notes/ Other Info: This technology may be applicable to detetion and monitoring during LTS. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: X-Ray Fluorescence Spectroscopy for Heavy Metals

Tech #: 143

Ref ID: 622

Date Available:

Past Investment($K): 0

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

SCFA

Description: In situ x-ray fluorescence spectroscopy with a downhole probe can provide an quantitative indication of heavy metal content in soils above the water table with minimal sample preparation and data evaluation. It can be used for site investigations and post-closure monitoring, since the probe can simultaneously determine the concentrations of a broad range of contaminants.

Expected Capabilities: The purpose of this project is to develop a downhole X-ray Fluorescence (XRF) spectrometer for detecting and quantifying inorganic contaminant concentrations in soils above the water table. The XRF instrument consists of an X-ray source and a photon detector. The instrument probe is placed in a lined borehole created by a cone penetrometer or drilling device. The liner must be very thin, such as a membrane liner, to allow transmission of the relatively low-energy X-rays. The surrounding soil and the detector are then irradiated with the source X-rays for a specified period of time. The detector receives a combination of Compton backscatter photons as well as fluorescence photons emitted by certain atoms in the soil. Real-time assays of soil constituents can be performed when the instrument system is properly calibrated. The system also includes an analog-to-digital converter, a multi-channel analyzer, and a computer processor. Calibration of the instrument for a particular element and observation of the number of counts appearing in specific fluorescence range of the energy spectra results in a real-time quantitative determination of the concentration of the element in the soil as a function of depth within the well.

Sources: TMS; Tech ID: 622

Notes/ Other Info: This technology may be used for post-closure monitoring. Terminated, development completed through Gate 6.

Techn. Name: Gamma-Ray Spectrometer

Tech #: 146

Ref ID: 626

Date Available:

Surveillance and Monitoring-Instruments/Sensors/Devices

Past Investment($K): 0

Future Investment($K): 0

SCFA

Description: Before any effective remedial protocols can be established, the three-dimensional distribution of the contaminants must be adequately characterized. Recent field studies at the FEMP ID site have demonstrated that real-time in situ gamma-ray spectrometry is ideal for the radiological characterization of large areas in a relatively short period of time. Unfortunately, the current technology utilizes bulky power supplies and data acquisition hardware, as well as inconvenient and potentially hazardous cable spans; this combination is cumbersome and awkward for a single operator to manipulate quickly in the field. The individual detection units frequently require nearly constant monitoring by a qualified spectroscopist, and count for a preset length of time at each sampling point regardless of the local level of contamination. Furthermore, a knowledge of the vertical distribution of the contamination at each sampling location is critical to the data-reduction process, thereby necessitating the collection of myriad soil cores and the consequent generation of secondary waste. These factors lead to undue and excessive ecpenditures in terms of dollars, effort, and actual labor hours.

Expected Capabilities: The focus of this effort is to devlop and evaluate an improved in situ gamma-ray spectrometer for use in characterizing radionuclide-contaminated sites. In addition to the demonstrated practical use of the complete system for the rapid and efficient mapping of uranium contamination at various sites, the principal objectives include establishing: 1) a compact data-acquisition unit, 2) a software-driven distributions, and 3) a user-friendly data-reduction software package.

Sources: TMS; Tech ID: 626

Notes/ Other Info: This technology may be utilized to characterize contaminants during LTS. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Vadose Zone Monitoring System

Tech #: 36 | **Date Available:** 9/30/1999 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 647 | **Past Investment($K):** 1124 | **Future Investment($K):** 0 | **SCFA**

Description: Post-closure monitoring is required of almost all remediated sites. The standard practice is to monitor ground-water wells for the presence of contaminants. This approach may be problematic at a site with great depth to ground water. By the time contaminants are detected in the ground water, significant vadose zone contamination will have occurred. Monitoring the vadose zone beneath the remediated site instead of the ground water would permit detection of a contaminant release with a smaller contaminant volume, and will result in a less costly additional remediation effort. Use of this technology will improve characterization and monitoring efforts. Better data on contaminant distribution and on the effectiveness of remediation efforts will reduce the cost of remediation projects. The entire system is low maintenance and can run unattended in the field for days. Equipment can operate over a wide range of environmental conditions, therefore only a ventilated rain-proof enclosure is required. Specific cost of the system comprise the purchase of the system components (approximately $40,000) as well as operation and maintenance costs.

Expected Capabilities: The Vadose Zone Monitoring System provides unattended, automated monitoring of multiple vapor sampling locations for unsaturated zone measurements. The vadose zone is the unsaturated area between the ground surface and the water table. Deep vadose zone refers to sites where the water table is generally deeper than 100 feet. Movement of vapor or volatile contaminants in the vadose zone is by diffusion or advection. Movement by diffusion is a result of a concentration gradient, while advective movement forces vapor or volatile contaminants through the vadose zone by some means, such as changes in barometric pressure with time. By utilizing the Vadose Zone Monitoring System the predominant mechanism of vapor or volatile contaminant movement can be made and, hence, provide more accurate predictions of the rate of movement of the contaminants to the water table.

Sources: TMS; Tech ID: 647

Notes/ Other Info: This technology is for post-closure monitoring.

Techn. Name: SCAPS

Tech #: 155 | **Date Available:** 9/30/2000 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1144 | **Past Investment($K):** 511 | **Future Investment($K):** 0 | **SCFA**

Description: The Site Characterization and Analysis Penetrometer System (SCAPS) can be used to characterize and investigate hazardous waste and DOE sites throughout the country. SCAPS is mounted on a cone penetrometer truck and can be used for rapid characterization of subsurface environments using push probes for investigation and sampling.

Expected Capabilities: The Site Characterization and Analysis Penetrometer System (SCAPS) is used to characterize and investigate the subsurface of hazardous waste and DOE sites. SCAPS is mounted on a cone penetrometer truck and can be used for rapid characterization of subsurface environments using push probes for investigation and sampling. The SCAPS technique will allow in-situ measurement of geophysical and physical properties of soils and stratigraphic units, as well as the determination of the presence of contaminants at a site without the extensive use of drilling and monitoring well installation. The SCAPS will also be used to collect soil and water data that will provide better definition of the zones of contamination, enabling more accurate placement of remediation systems and monitoring wells. DOE's major objective is to operate the SCAPS for evaluation and for further technology improvements to both the vehicle and its components. In addition, it is also DOE's objective to ensure that this technology is then transferred to industry, thus providing a rapid and cost-effective tool for implementation in site characterization investigations at hazadous waste sites throughout the country.

Sources: TMS; Tech ID: 1144

Notes/ Other Info: This technology may be utilized to characterize and monitor LTS sites. Terminated after Gate 5, awaiting decision for deployment.

Techn. Name: Contamination Control Unit

Tech #: 156 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1190 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: The Rapid Transuranic Monitoring Laboratory (Contamination Control Unit) is a field-deployable mobile laboratory that provides Environmental Restoration and Waste Management programs throughout the Department of Energy (DOE) complex the capability to monitor airborne alpha-emitting Transuranic (TRU) isotopes and analyze soil, smear, and air filter samples for alpha-emitting TRU isotopes and gamma-emitting radionuclides using direct spectrometer methods.

Expected Capabilities:

Sources: TMS; Tech ID: 1190

Notes/ Other Info: This technology may be utilized to monitor soil, air, and water during LTS. Terminated after Gate 5, transferred to user or industry to complete.

Techn. Name: In Situ Fiber Optic Derivative Ultraviolet Absorption Spectroscopic (DUVAS) Monitoring of Aromatic Contaminants

Tech #: 164 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1293 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 1293

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to monitoring during LTS. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: Advanced Fiber-Optic Sensor Systems

Tech #: 165 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1304 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 1304

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to monitoring and sensors during LTS.

Techn. Name: Transuranic (TRU) Waste Characterization

Tech #: 166 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1324 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 1324

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to characterizing during LTS. Terminated after Gate 4, awaiting decision for deployment.

Techn. Name: Hydraulic Conductivity Measurement and Stabilization Verification

Tech #: 172 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1746 | **Past Investment($K):** 106 | **Future Investment($K):** 0 | **SCFA**

Description: This project addresses the remediation of buried waste and landfills throughout the weapons complex. The real time, high resolution imaging capabilities of the ground penetrating holographic (GPH) system provides location and orientation data of buried waste. TTP#s RL17SS41 and RL37SS41 describe development and deployment of a low frequency electromagnetic ground penetrating holographic system (LEMA) for imaging subsurface objects such as buried waste, etc. in low resistance soils.The proposed system, which could be potentially mounted on a manned or remote controlled vehicle or excavation equipment, will be capable of generating real-time images of deep buried waste at various DOE sites. The GPH technology (LEMA and 2.5 GHz array) will be used to determine the location, depth, and size of buried materials.

Expected Capabilities:

Sources: TMS; Tech ID: 1746

Notes/ Other Info: This technology may be utilized to provide mapping of buried material during LTS. Terminated after Gate 6 because lower priority than could be covered by available funding.

Techn. Name: Multi-sensor Analysis Program for Environmental Restoration (MAPER)

Tech #: 176 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1861 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description: The purpose of this task (AL26LF42) is to enhance the Landfill Assessment and Monitoring System (LAMS) Multi-Sensor Analysis Program for Environmental Restoration (MAPER) target verification and data visualization system (MAPER) to incorporate GPR and EM data evaluation capability, to allow the input of field notations and health/safety equipment readings, and to be field portable and near real time.

Expected Capabilities:

Sources: TMS; Tech ID: 1861

Notes/ Other Info: This technology is applicable to monitoring during LTS. Terminated after Gate 5, transferred to user or industry to complete.

Techn. Name: **Portable Selective Hot Spot Removal System**

Tech #: 177	**Date Available:**	9/30/1997	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 1863	**Past Investment($K):**	2250	**Future Investment($K):**	0	**SCFA**

Description: he purpose of the Hot Spot Removal System is to locate and remove source terms at selective retrieval and small scale (< 500 cubic yards) full retrieval locations. Removing the source term will reduce the risk of the area at the same time as reducing the volume of waste removed, subsequently reducing the cost of retrieval, assay, handling, treatment, storage, and disposal.

Expected Capabilities: The objective of this program is the development and deployment of a low frequency ground penetrating holographic system for imaging subsurface objects such as buried waste in low resistance soils. The proposed system, which could be potentially mounted on a manned or remotely-controlled vehicle or excavation equipment, will be capable of generating real-time images of deeply buried waste at various DOE sites.

Sources: TMS; Tech ID: 1863

Notes/ Other Info: This technology may be applicale to mapping hot spots below the surface during LTS. Terminated after Gate 5 because lower priority than could be covered by available funding.

Techn. Name: Rapid Geophysical Surveyor

Tech #: 183 | **Date Available:** 9/30/1995 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 1995 | **Past Investment($K):** 100 | **Future Investment($K):** 0 | **SCFA**

Description: The Rapid Geophysical Surveyor (RGS) is a passive, nonintrusive measurement system that automates the collection of high-spatial-resolution geophysical data. Closely spaced data are required to adequately characterize complex buried-waste areas commonly found in the DOE, Department of Defense, and private sectors. The system measures and associates the local magnetic field with precision positioning in a systematic fashion. Variations in the Earth's local magnetic field are indicative of subsurface ferromagnetic material which is a common component of buried wastes.

Expected Capabilities: The Rapid Geophysical Surveyor consists of magnetic-field sensors, a calibrated measuring wheel, and a microprocessor-based data logger mounted on a hand-pushed, non-ferrous vehicle. The data logger utilizes menu-driven software so that the key field survey parameters can be configured by the user. The user is required to push a 20-lb cart to collect magnetic data. Magnetic data are automatically collected and stored at user-specified intevals as close as 2-in. apart along survey profile lines. These data form a high-resolution database capable of locating individual objects and potentially determining object orientation, shape, and depth to burial. There is no input required for this passive system, and the output of the RGS is a set of spatially correlated magnetic data.

Sources: TMS; Tech ID: 1995

Notes/ Other Info: This technology may be applicable for characterization during LTS. Terminated, development completed through Gate 6.

Techn. Name: Segmented Gate System

Tech #: 186	**Date Available:**	9/30/1998	Surveillance and Monitoring-Instruments/Sensors/Devices		
Ref ID: 2158	**Past Investment($K):**	2935	**Future Investment($K):**	0	**SCFA**

Description: The Segmented Gate System (SGS) uses a computer controlled mechanical sorter to separate suspected radioactive contaminated soil into clean and contaminated waste streams. This is accomplished by passing soil, via a conveyor belt, under two banks of sensors that will detect radionuclide concentrations above the desired limits based on the specific contaminant and regulatory requirements. This soil is then diverted into a separate waste stream for removal. The SGS is capable of using a variety of sensors required for specific contaminant detection (i.e., sodium iodide, calcium fluoride, or high purity germanium). The flexibility, sensitivity, and speed of the SGS has proven to be cost effective and significant volume reduction has been experienced.

Expected Capabilities:

Sources: TMS; Tech ID: 2158

Notes/ Other Info: This technology may be utilized to detect contaminants during LTS.

Techn. Name: **Reactive Barrier Performance: DNAPL**

Tech #: 40

Ref ID: 2187

Date Available:	
Past Investment($K):	650

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	500

SCFA

Description: The overall objective of this project is to evaluate and maximize the effectiveness of permeable reactive barriers (PRB) through development of a broad-based working group with participation from the Department of Energy, Department of Defense, the Environmental Protection Agency, academia and industry in advancing the PRB technology. Using the Remediation Technology and Development Forum (RTDF) permeable barriers consortium as a base, the researchers will coordinate this work with DOD and EPA at the national level. Specific objectives are (1) develop sampling sampling protocols and monitoring methods for PRB, (2) evaluate biogeochemical and hydraulic performance of PRBs and mitigate complications (fouling and plugging) caused be biogeochemical and hydraulic processes, and (3) devise and implement long-term monitoring strategies through the use of hydrological and geochemical models. The project will develop monitoring methods that will provide early warning of incipient barrier failure and recommend long-term monitoring protocols to minimize costs.

Expected Capabilities: The specific objectives are to (1) develop sampling protocols and monitoring methods for permeable reactive barriers, (2) evaluate biogeochemical and hydraulic performance of permeable reactive barriers, and mitigate complications caused by biogeochemical and hydraulic processes, and (3) devise long-term monitoring strategies.

Sources: TMS; Tech ID: 2187

Notes/ Other Info: SCFA identified this technology as applicable to LTS.

Techn. Name: Electrical Impedance Tomography (EIT)

Tech #: 195 | **Date Available:** | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 2205 | **Past Investment($K):** 0 | **Future Investment($K):** 0 | **SCFA**

Description:

Expected Capabilities:

Sources: TMS; Tech ID: 2205

Notes/ Other Info: There is no data entered in TMS for this technology, however the title suggests it may be applicable to mapping contaminants in the subsurface during LTS.

Techn. Name: Improved Surface Water Monitoring for Radionuclide Discharges

Tech #: 35 | **Date Available:** 9/30/1999 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 2913 | **Past Investment($K):** 416 | **Future Investment($K):** 0 | **SCFA**

Description: Thousands of surface water samples are collected and analyzed each year by the Department of Energy (DOE) and contractors at the individual sites to provide supporting data for Annual Environmental Reports. This technology, with the support of the 3M Company and ISCO, Inc., has been developed and demonstrates an improved in-situ processing method for monitoring radionuclide concentrations in surface streams. This method is equally applicable to monitoring radionuclide discharges from different points.

Expected Capabilities: This technology assist in the collection and analysis of water samples, and when placed at effluent monitoring points for remediation activities, the use of this in-situ sample processing can reduce programmatic risks for cleanup activities by providing for rapid sample analyses, thereby allowing quicker response to process starts or upsets.

Sources: TMS; Tech ID: 2913

Notes/ Other Info: This technology may be used for monitoring during LTS.

Techn. Name: Cone Penetrometer Sensor Testing and Evaluation

Tech #: 38

Ref ID: 2921

Date Available:	9/30/2001
Past Investment($K):	400

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K):	100

SCFA

Description: The cone penetrometer is becoming the tool of choice for environmental site characterization in unconsolidated and semi-consolidated formations because it allows rapid, cost-effective access to the subsurface. Many sensors and probes for the cone penetrometer are under development by DOE´s Office of Science and Technology, DOE, DOD, and others. These new sensors are often difficult to implement due to the limited documented and validated cost and performance data. These data are required for procurement, regulatory, and performance regulations and guidelines. This task demonstrates these sensors and probes and collects these data to enable their deployment. These sensors are integrated into a package called the DNAPL characterization tool box that includes: Electronic Cone Penetrometer Sensors for Lithologic Delineation, Laser-Induced Fluorescence Probe, Precision Injection/Extraction Probe, FLUTe´s Hydrophobic Flexible Membrane also known as the Ribbon NAPL Sampler, Field Raman Spectrograph, GeoVis Soil Video Imaging System, Cone Sipper Groundwater Sampler, SSA Cone Permeater, Geoprobe Membrane Interface Probe.

Expected Capabilities: This technology is applicable at Portsmouth Gaseous Diffusion Plant and Lawrence Berkeley National Laboratory.

Sources: TMS; Tech ID: 2921

Notes/ Other Info: This technology is used for site characterization. SCFA identified this as direct application to LTS.

Techn. Name: Enhanced Site Characterization System

Tech #: 196 | **Date Available:** 9/30/1999 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 2922 | **Past Investment($K):** 250 | **Future Investment($K):** 0 | **SCFA**

Description: The Enhanced Site Characterization System uses geostatistical techniques to integrate multiple environmental data sets (e.g., geophysical data, chemical and radiological characterization data), and produces an integrated 3D conceptual model of the distribution of various waste types in the burial ground. The resulting map aids planning of excavation. Improved planning reduces economic and health and safety risks during excavation, and reduces remediation costs.

Expected Capabilities:

Sources: TMS; Tech ID; 2922

Notes/ Other Info: This technology may be utilized during LTS to characterize and monitor contaminants.

Techn. Name: Novel Hotpoint DNAL Detector for Subsurface Analyses

Tech #: 199 | **Date Available:** 9/30/2003 | Surveillance and Monitoring-Instruments/Sensors/Devices

Ref ID: 3044 | **Past Investment($K):** 715 | **Future Investment($K):** 420 | **SCFA**

Description: Significant technology gaps limit our ability to characterize the iventory and distribution of contaminants in the vadose and saturated zones. The ideal solution to DNAPL analyses is to collect and present to the detector an amount of DNAPL from a much larger volume of soil. This technology provides an in situ method to heat a significant volume of soil around a penetrometer probe within several minutes (103-106 times > than ambient sampling/detection), and capture and route vaporized DNAPL from this volume to a senstive in situ detector/sampler.

Expected Capabilities:

Sources: TMS; Tech ID: 3044

Notes/ Other Info: This technology may be utilized for characterization and sampling during LTS.

Techn. Name: **Mapping DNAPL Transport and Contamination in Sedimentary and Fractured Rock Aquifiers with High Resolution Borehole Seismic Imaging**

Tech #: 37

Ref ID: 3045

Date Available:	5/25/2001
Past Investment($K):	359
Future Investment($K):	359

Surveillance and Monitoring-Instruments/Sensors/Devices

SCFA

Description: Currently the only technology to map DNAPL distribution is extrapolating between point measurements in boreholes. This is often inadequate because of the heterogeneity in both sedimentary and fractured rock aquifers, and the likelihood of missing important features that do not intersect the boreholes. The proposed technology will directly image areas not sampled by boreholes. It aims to provide high resolution images of DNAPL distribution changes between and away from boreholes, and potentially direct detection of DNAPL, providing detailed information on geologic structure which can be used to improve predictive transport models. It will monitor effects of remediation on DNAPls source-term removal with crosswell and single well seismic and possibly radar measurements. In fractured systems, it will directly image not only the fracture systems but the important fractures controlling DNAPL distribution, changes over time, and potentially DNAPL within the fractures.

Expected Capabilities: Currently the only technology to map DNAPL distribution is extrapolating between point measurements in boreholes. This is often inadequate because of the heterogeneity in both sedimentary and fractured rock aquifers, and the likelihood of missing important features that do not intersect the boreholes. The proposed technology will directly image areas not sampled by boreholes. It aims to provide high resolution images of DNAPL distribution changes between and away from boreholes, and potentially direct detection of DNAPL, providing detailed information on geologic structure which can be used to improve predictive transport models. It will monitor effects of remediation on DNAPls source-term removal with crosswell and single well seismic and possibly radar measurements. In fractured systems, it will directly image not only the fracture systems but the important fractures controlling DNAPL distribution, changes over time, and potentially DNAPL within the fractures.

Sources: TMS; Tech ID: 3045

Notes/ Other Info: This technology maps and monitors the effects of remediation.

Techn. Name: Cone Penetrometer Off-Surface Sensor-CNAPLs in Vados Zone

Tech #: 200

Ref ID: 3046

Date Available:	6/30/2001
Past Investment($K):	125
Future Investment($K):	25

Surveillance and Monitoring-Instruments/Sensors/Devices

SCFA

Description: Significant technology gaps limit our ability to understand the inventory, distribution , and movement of contaminants in the vadose zone and to predict the movement and fate of these contaminants. There are currently several treatment options available for DNAPL that require location and distribution be described so that the treatment can effectively target the high concentration areas. Current techniques to measure DNAPL in the vadose and groundwater using sensors attached to cone penetrometers exist. However, no single sensor can repeatedly detect and measure DNAPL concentrations in all soils. The Cone Penetetrometer Off-Surface Sensor (CPOSS) tool has been completed without attached sensors.

Expected Capabilities:

Sources: TMS; Tech ID: 3046

Notes/ Other Info: This technology is intended to improve the monitoring of the movement of contaminants in the vadose zone during LTS.

Techn. Name: Vadose Zone Monitoring Hanford Site Surface Barrier

Tech #: 39

Ref ID: 3132

Date Available:

Past Investment($K): 200

Surveillance and Monitoring-Instruments/Sensors/Devices

Future Investment($K): 0

SCFA

Description: A testing and monitoring program was initiated at the Prototype Hanford Barrier in October 1995. This new project will use the unique facilities provided by the prototype barrier to establish an adequate record of long-term performance and to demonstrate and evaluate techniques capable of monitoring performance of field-scale covers. This work builds on the 10 years of experience at Hanford that culminated in the construction of a full-scale, instrumented, research cover over an existing waste site. Many of the monitoring technologies employed at the Hanford Barrier are also applicable to measurement of hydraulic and transport properties in the vadose zone. Thus, capitalizing on this existing cover for the studies proposed herein represents significant cost savings to the DOE´s barrier development program. The work in this proposal will complement existing programs at other sites and satisfy the technology development needs identified by Hanford STCG for FY2000 and beyond.

Expected Capabilities:

Sources: TMS; Tech ID: 3132

Notes/ Other Info: This technology monitors the performance of barriers. Identified as LTS applicability by SCFA.

Techn. Name: Contaminant Transport Modeling Studies of Russian Sites

Tech #: 62

Ref ID: 775

Date Available:		Surveillance and Monitoring-Subsurface Science		
Past Investment($K):	370	**Future Investment($K):**	400	**SCFA**

Description: Nuclear fuel cycle activities in Russia have resulted in significant contamination of the environment in western Siberia. The West Siberian Basin contains the largest amounts of surface and subsurface radioactive contaminants on earth. Pacific Northwest National Laboratory is developing, jointly with their Russian counterparts in the Ministry of Atomic Energy of the Russian Federation (MINATOM), three-dimensional numerical models of the hydrogeology and potential contaminan migration in the West Siberian Basin to verify and validate DOE models and modeling strategies using decades of data from measured contaminant migration at the Mayak, Tomsk-7, and Krasnoyarsk-26 sites.

Expected Capabilities: The objectives of the project are: 1) document results of the regional hydrogeologic model of the West Siberian Basin; 2) develop and document the spatially registered, digital geologic and hydrologic databases derived from open-literature sources and direct interactions and subcontracting with MINATOM, that will provide a common database for joint U.S.-Russian modeling in geographic information system format; 3) implement the conceptual and computer models of the hydrogeology of Tomsk; and 4) perform preliminary joint U.S.-Russian hydrogeologic contaminant-transport model inter-comparison studies for Mayak.

Sources: TMS; Tech ID: 775

Notes/ Other Info: Identified by SCFA as a technology related to LTS.

Techn. Name: Hanford Vadose Zone Characterization (Flow & Transport Process)

Tech #: 202

Ref ID: 3047

Date Available:	6/4/2001
Past Investment($K):	430

Surveillance and Monitoring-Subsurface Science

Future Investment($K):	425

SCFA

Description: Deployment of Through Casing Resistivity Technology (TCRT) is based on the assumption that surrogate information, namely electrical resistivity, can be used to determine the distribution of water and contaminants in the subsurface. TCRT has been demonstrated primarily in the petroleum industry for detecting oil or gas in bypassed formation using the existing well infrastructure. In Hanford tank farms, steel cased wells limit the use of most electrical methods for subsurface characterization. TCRT has the potential to overcome these limitations. The technique uses existing steel cased wells as electrodes in one technique and in another as access tubes for a through casing resistivity tool. Using new high-speed inversion algorithms, TCRT promises to yield an important technique for high-resolution vadose zone characterization, using existing steel cased boreholes, at scales relevant to remediation and risk assessment.

Expected Capabilities:

Sources: TMS; Tech ID: 3047

Notes/ Other Info: This technology may be utilized to display the distribution of contaminants in the subsurface during LTS.

EM-50 Category: TFA

Techn. Name: Vadose Zone Characterization System

Tech #: 74

Ref ID: 2118

Date Available: 10/1/1999

Past Investment($K): 3854

Surveillance and Monitoring-Subsurface Science

Future Investment($K): 0

TFA

Description: The Vadose Zone Characterization System, developed through the Hanford Tanks Initiative project, includes improved technology for measuring contaminants that have leaked from the tanks to the groundwater. The Vadose Zone Characterization System consists of three components: the Cone Penetrometer, a multisensor package, and a multipoint soil sampler. Alternative technologies to conventional core drilling for characterization of the vadose zone that are fast, economical and minimize intrusion to the vadose zone will be developed for detailed plume mapping and quantification of the waste currently in the soil. The cone penetrometer deployment platform will be used to deploy multi-sensor probes and a sample retrieval system to determine the extent of contamination and to obtain samples for confirmatory analysis.

Expected Capabilities: The Hanford Tanks Initiative Vadose Zone Characterization System includes improved technology for measuring contaminants that have leaked from the tanks to the groundwater. The technology provides rapid, cost effective assistance in defining contaminant plumes. Cost savings of 30 to more than 60% can be obtained by using the system to screen an area and optimize the location of permanent monitoring boreholes. Compared to drilling, the technology generates minimal amounts of waste and minimizes disturbance of the subsurface that can lead to deeper migration of contamination.

Sources: TMS,IPABS OST

Notes/ Other Info:

EM-50 Category: TMFA

Techn. Name: Nochar Petrabond(R) Absorbent Polymer

Tech #: 286

Ref ID: 2313

Date Available:	9/1/2001	Physical Barriers-Waste Forms	
Past Investment($K):	488	**Future Investment($K):**	250

TMFA

Description: Nochar is a commerical low termperature stabilization process for mixed waste. is a high technology polymer solidifying agent that can provide a simple and effective disposal method for tritiated oil. The NoChar Petroset organic based binder is being evaluated as a method to immobilize TRU oils at Rocky Flats and spent reprocessing solvent at the Savannah River site. The Nochar agent will absorb oil with no mixing or required mixing equipment, and with a combination or ´formula´ of high tech polymers can be specifically designed to address the characteristics of waste oil as it exists at a given site. The product can be effectively used for free liquid control in storage, transport, and disposal of radioactive and RCRA defined waste oils. Petro Bond Polymer Crystals are non-toxic, non-biodegradable and incinerable to less than 0.02% ash with an absorbent capacity of up to 15:1 (oil to solidification agent ratio by weight).

Expected Capabilities:

1. Solidifies liquid organics for shipment of TRU wastes to WIPP
2. Stabilizes RCRA heavy metals in organic based MLLW
3. May reduce hydrogen generation in TRU organic sludge drums
4. Low temperature processing

Sources: TMS

Notes/ Other Info: Notes: The test procedures developed, as well as the data they eventually provide, may go along way in determing the integrity of waste forms over the time periods reflective of a long-term stewardship program. It is being co-funded by the TMFA and DDFA.